Ecology of the Tule Elk Range, Point Reyes National Seashore

By

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POINT REYES NATIONAL SEASHORE

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ABSTRACT

Tule elk (Cervus elaphus nannodes) were extirpated from the coastal prairie-coastal scrub mosaic of the Point Reyes Peninsula, Marin Co., California sometime after the 1860's as the area was developed for livestock production. The reintroduction of tule elk to the Tomales Point portion of the Peninsula in March 1978 precipitated a study of ecological interactions of native mammalian herbivores and vegetation as livestock use was halted (November, 1979).

Vegetation of Tomales Point was categorized to three grassland types and one scrub type. Grasses constituted most of the plant cover in all grassland types in 1980 and 1981. In the scrub type, shrubs were dominant in 1980 but forbs predominated in 1981. Peak herbaceous standing crop was recorded in June, ranging between 310 gm/m^2 and 810 gm/m^2 among the grassland types. Estimates of annual productivity of herbaceous vegetation ranged between 207 and 370 gm/m^2, with the greatest production occurring

between February and June.

Population growth of tule elk reintroduced to Tomales Point was compared to that growth of tule elk reintroduced to Grizzly Island, Solano Co. Elk at Grizzly Island grew at the maximum potential rate while those at Tomales Point grew at half the theoretical potential. The lower rate of growth was attributed to an initial pulse of adult mortality, low calving rates and high subadult mortality. Analysis of serum and hair samples showed adult mortality and low calving rates were due in part to copper deficiency. Subadult mortality was caused by paratuberculosis. Radiographs of elk antlers suggested that nutritional stress was not restricted to copper deficiency alone. Prior to cattle removal there was very little available forage for elk.

Elk translocated to Tomales Point exhibited strong social cohesiveness. The home range of the single cow-calf group consisted of 360 to 420 ha, centered in the southern portion of Tomales Point.

Black-tailed deer (<u>Odocoileus hemionus columbianus</u>) density was determined by nine monthly line-transect censuses and four bimonthly pellet-group samples between

November 1980 and September 1981. Line transect density estimates ranged between 0.07 and 0.29 deer/ha. Pellet-group sample estimates ranged between 0.16 and 0.33 deer/ha. Both methods produced an estimate of 0.21 deer/ha with a standard error of 0.07 in February 1981. Composition counts suggested a deer population with a high adult buck:doe ratio and a relatively low reproductive rate and low fawn survival, as would be expected for an unharvested population at ecological carrying capacity.

Estimates of density of California voles (Microtus californicus) determined by mark-recapture and runway count methods suggest a fluctuating population with densities ranging between 1.9 and 20.9 voles/ha. Other rodents were much less abundant and included: deer mouse (Peromyscus maniculatus) and western harvest mouse (Reithrodontomys megalotis).

Elk and deer on Tomales Point may be classified as forb-grass and forb-shrub feeders, respectively, with both species utilizing forbs extensively in the spring and summer months when herbaceous standing crop is high. The greatest dietary overlap occurs in the summer months. Both ungulates exhibited a pattern of optimizing nutrient intake.

Habitat suitability index (HSI) models were developed for elk and deer. The HSI model for deer was tested using pellet-group count data. The results were inconclusive.

Three estimates of carrying capacity for elk on Tomales Point range from 90 at optimum density (ICC) to 350 at subsistence density with 140 identified as the best estimate of KCC presently available. Carrying capacity may be expected to decline if coyote bush (Baccharis pilularis) continues to invade areas of open grassland or if the important forage plant English plantain (Plantago lanceolata) becomes less abundant through successional changes. Prescribed fire may be used to reverse these processes.

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CHAPTER I

INTRODUCTION

In pristine times tule elk (Cervus elaphus nannodes) occurred in great herds throughout California's central valley and in smaller bands along the coastal ranges from Sonoma County, to Santa Barbara County (McCullough 1969). This endemic subspecies is now classified as rare by the U.S. Department of Interior (Tule Elk Interagency Task Force 1979) and state legislation requires number of the subspecies be increased to 2,000, if suitable habitat is available, before it may be classified as a game species (Tule Elk Interagency Task Force 1979). Ultimate responsibility for management of tule elk lies with the California Department of Fish and Game and Fish and Game Commission (Tule Elk Interagency Task Force 1979). The Department has been relocating tule elk since 1974. In 1978, federal agencies with responsibility for federal lands within the tule elk's original range were instructed by Congress to make suitable lands available for re-establishment of viable populations (Tule Elk Interagency Task Force 1979). Tule elk were reintroduced to a 1030 ha portion of Tomales Point the same year.

The California Department of Fish and Game wishes to

comply with the legislated mandate as quickly as possible in order to return the tule elk to the status of a game species (B. E. Curtis, pers. comm.). The economic incentive to private landowners in permitting reintroductions of tule elk under the State's Private Lands Act hinges on the subspecies' reclassification as a game species. The Department recognizes the need to eliminate concerns about inbreeding depression by actively moving of tule elk between isolated populations (D. A. Jessup, pers. comm.).

The National Park Service is responsible for management of the Tule Elk Range on Tomales Point within the context of: 1) Service-wide management policies; 2) Point Reyes National Seashore's enabling legislation; and 3) subsequent designation of most of Tomales Point as a wilderness zone. The wilderness designation stresses the National Park Service's intent to re-establish a natural ecosystem on Tomales Point. Yet, some of the natural ecosystem's original components have been eliminated and many of the feedback mechanisms may operate only partially or not at all. A variety of taxa have been extirpated and others have been introduced. Artificial barriers and the small size of the ecosystem may affect many natural processes.

Removal of livestock from and reintroduction of tule elk to the coastal prairie-coastal scrub mosaic of Tomales Point represents a major perturbation to the range-herbivore system. This system may go through a number of perturbations before a new equilibrium is achieved with elk and deer as dominant vertebrate herbivores. The response of natural processes to such factors is difficult to predict. The National Park Service is charged with managing most of Tomales Point as a natural area and wilderness zone (National Park Service 1978a,b). "Evolved policies for these natural areas restrict management to protecting against, removing or compensating for human influence that cause departures from natural conditions." (Cole 1971:417). Thus, the Park Service may find it necessary to intervene with management practices to maintain natural conditions (Leopold et al. 1963, Cole 1971).

Successful management requires a thorough understanding of the past history and present trends in the dynamics of the inorganic and organic components of the system to the extent that future outcomes may be predicted. A long-term ecological monitoring program provides the ideal framework in which to obtain the required information. Grimsdell (1978:2-3) points out that monitoring programs: 1) measure

the ecosystem's stability; 2) test the reliability of predictive models; 3) give warning of trends judged undesirable in a nature reserve; 4) provide information for development of management plans; and 6) evaluate the success of management programs. Monitoring also provides a means of re-evaluating management goals.

Reintroduction of ungulates has become popular throughout the world, with varied levels of success. The paucity of information on the population ecology of ungulate species in the early years of introductions has caused researchers to go so far as simulating introductions (McCullough 1979). Generally, introduced ungulate populations have shown a remarkable ability to multiply. Such growth is traditionally described by some form of the logistic curve, which may be represented mathematically (May 1981a,b) by:

$$dN/dt = r_m N(1-N/k) \qquad (1)$$

that is, the rate of change in numbers (dN/dt) is the product of the intrinsic rate of increase of the population (rm), the number (N) of animals alive at the beginning of time t, and a factor (N/k) which measures the ratio between the total number of animals an area can support (K), and

the number present. As this ratio approaches unity, dN/dt approaches zero.

Caughley (1976) suggested that a delayed logistic growth curve describes an increasing ungulate population more realistically than the simple logistic curve. The former incorporates a factor (t) to account for a time lag in the population's response to changes in animal numbers relative to resources (N/k). The mathematical expression for this curve is:

$$dN(t)/dt = rmN(1-(N(t-T))/K) \qquad (2)$$

or, the " ... rate of increase per head at time t is the intrinsic rate of increase multiplied by the component of the proportion of the carrying capacity size K the population has reached by time (t-T) ..." (Caughley 1976:204).

The potential impact of reintroduced tule elk upon black-tailed deer (<u>Odocoileus hemionus columbianus</u>) is an issue. The equations for logistic growth of two species' populations utilizing the same resources require an additional component to express the inhibitory effect of each species on one another. Thus, the formula presented

initially may be expanded for each population as:

$$dN_1/dt = r_{m1} \ (1-N_1 XN_2/K1) \qquad (3)$$

and

$$dN_2/dt = r_{m2} \ (1-N_2 BN_1/K_2) \qquad (4)$$

where the component B/K_2 represents the inhibitory effect of population one on the growth of the second population, and X/K_1 is the inhibitory effect of the second population on the first (May 1981b).

Previous field studies have examined the impact of elk on deer populations. A study of the effects of increasing Rocky Mountain elk (C. e. nelsoni) numbers on mule deer (O. h. hemionus) showed the elk population increasing at a rate some ten percent greater than deer although deer have a higher potential rate of increase (Cliff 1939). Elk inhibition of deer population growth was attributed to the larger species ability to gain access to more forage on the winter range because of their greater height and strength (Cliff 1939). Rocky Mountain elk at Banff and Jasper National Parks, Alberta, are in direct competition with mule deer on winter range and have adversely affected deer numbers (Flook 1964). Studies of range utilization in

Montana (Mackie 1970) suggest direct competition for forage in the summer months between Rocky Mountain elk and mule deer. In contrast, Houston (1982) found little relationship between changes in elk population sizes and mule deer numbers in the northern Yellowstone region.

This report presents the findings of a study of elk-deer-range interactions on Tomales Point within the context of a pilot ecological monitoring program. The study was initiated by the National Park Service to achieve the following general objectives as set forth by the Tule Elk Interagency Task Force (Tule Elk Interagency Task Force 1979:22-23):

1) "Describe herd boundaries, herd migration patterns, and other factors which might affect local tule elk distribution.

2. Identify calving grounds, holding areas, and other critical areas.

3. Describe tule elk habitat requirements on a seasonal basis, including range production and use.

4. Identify the effects of natural mortality factors, conflicts with other wildlife, and existing land use patterns.

5. Evaluate recruitment potential based on habitat evaluation and present elk population composition."

These general objectives were expanded and refined for

the range-ungulate system on Tomales Point as modified by past and present land use to develop the following specific research tasks:

1. To identify general vegetative types and their distribution on Tomales Point.

2. To determine the biomass production of each vegetative type and incorporate appropriate methods into a monitoring program.

3. To establish permanent photographic stations covering the full spectrum of vegetative types on Tomales Point.

4. To evaluate seasonal utilization of vegetative types by each ungulate species and to compare the efficiency of direct and indirect sampling methods for future monitoring programs.

5. To determine seasonal forage utilization by elk and deer on Tomales Point.

6. To determine tule elk numbers, age and sex composition, reproductive rates, recruitment rates and mortality factors.

7. To determine black-tailed deer numbers, age and sex composition, reproductive rates, recruitment rates and mortality factors.

8. To estimate the total ungulate carrying capacity of Tomales Point and to investigate various combinations of elk and deer numbers that might occur at equilibrium and to predict when equilibrium could be expected under specified management programs.

Immediate concerns for the well-being of the reintroduced elk caused additional objectives to be added

to this study, including assessment of: 1) trace element deficiency; and 2) paratuberculosis in the tule elk. The impact of these diseases on elk population processes was highlighted by comparison to elk reintroduced to Grizzly Island Wildlife Management Area, Solano Co. A detailed assessment of plant communities (Lathrop and Gogan 1985) was prepared as an addendum to this report.

CHAPTER II

STUDY AREA

Location

The Point Reyes Peninsula, Marin County, is located along the central coast of California (Fig. 1). The tule elk range extends from the Peninsula's northernmost tip at Tomales Point to approximately 8 km south, the southern boundary being demarcated by a 2.5 m high drift fence, and embraces approximately 1030 ha referred to geographically as Tomales Point. The area was formerly the Pierce Dairy Ranch and is known locally as Pierce Point.

Geology and Soils

The backbone of the Point Reyes Peninsula consists of an isolated segment of Cretaceous plutonic granitic rock (Weaver 1949, Curtis et al. 1958, Galloway 1977). The San Andreas Fault Zone separates this formation from the Jurassic Franciscan rocks of the mainland (Bailey et al. 1964). The plutonic rock underlying Tomales Point, " ... ranges in composition from quartz diorite through granodiorite to adameilite." (Galloway 1977:15). Granitic rocky outcrops are present throughout the area. At Tomales

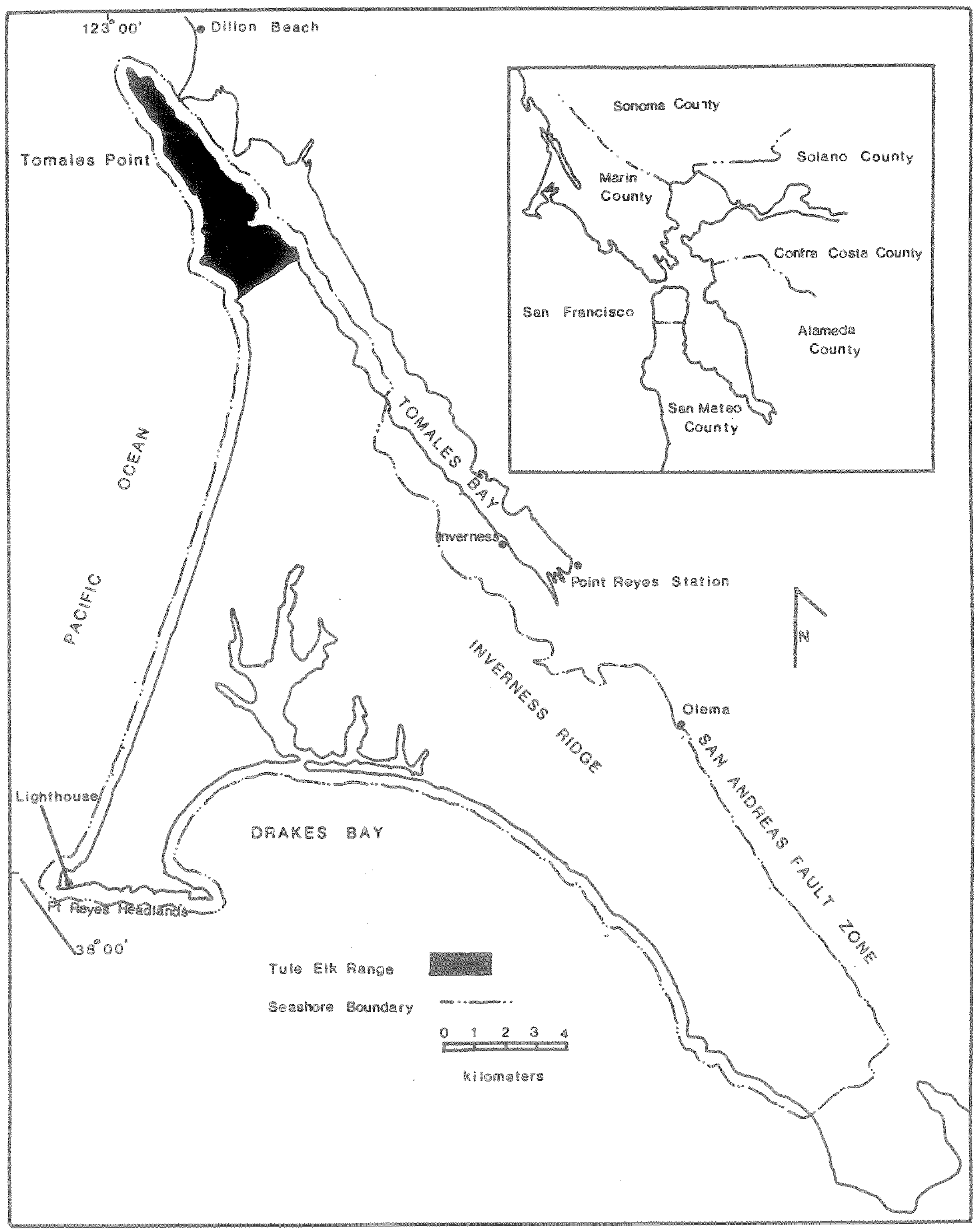


Figure 1. Location of Tomales Point on the Point Reyes Peninsula, central California.

Point, granodiorite occurs as wave-cut bluffs up to 45 m above sea level (Crawford et al. 1983).

Approximately 90% of the area is covered by a single soil type classified as the Kehoe Variant of the Sheridan Baywood Association (Soil Conservation Service 1967). Four other soil types cover the remaining 10% of the land mass (Table 1). Kehoe Variant soil is a coarse-loamy, mixed isomesic Pachic Haplustoll derived from the underlying granitic rocks (Soil Conservation Service 1967). The second most common soil is the Sirdak Variant of the Terrace Escarpment Association (Soil Conservation Service 1967). It is a sandy, mixed isomesic Ustic Dystropedt derived from wind-deposited beach sand or from uplifted beach deposits originating from weathered Franciscan rocks of the adjacent mainland (Galloway 1977). It is prevalent along the Point's western edge. Both soils' low water capacity, high susceptibility to wind erosion and steepness of slopes limit the area's suitability for livestock grazing (Table 1).

Mixed alluvial soils form freshwater aquepts, particularly along the Point's eastern slope adjacent to seeps. These Rodeo clay loam soils typically have an 8-16 cm horizon consisting of greater than 50% organic matter,

Table 1. Characteristics of soil types of Tomales Point (after Soil Conservation Service 1967).

Soil Type	Subsoil Permeability	Available Water Capacity	Effective Root Depth (m)	Water Erosion Hazard	Wind Erosion Hazard	Limitations for Livestock Grazing
Sirdak Sand	Rapid	Low	1.5+	Low	High	Steepness of slope; low water capacity; wind erosion
Kehoe Variant Coarse Sandy Loam	Moderately rapid	Low to moderate	1.0 - 1.5	High	Moderate	Low water capacity; wind erosion; steepness of slope
Sheridan Variant Coarse Sandy Loam	Moderately rapid	Very low to low	0.5 - 1.0	Moderate	Moderate	Woody plants; low water capacity
Kehoe Loam	Moderately rapid	Low to moderate	0.5 - 1.0	Moderate	Moderate	Low to moderate water capacity
Rodeo Clay Loam	Slow	High	1.5+	Slight	Slight	Slow permeability; seasonal water table

underlain by loam or clay loam (Akeson et al. 1982). Saline aquepts are common in embayments along Tomales Bay, but occupy only a small part of the total area. The saline aquept at White Gulch is typical (Akeson et al. 1982). It consists of, " ... stratified layers of silt, clay and organic matter and is ... continually waterlogged and very saline." (Akeson et al. 1982:12).

Kehoe Loam occupies two small knolls immediately east of the Upper Pierce Ranch (Soil Conservation Service 1967). It is a fine-loamy, mixed isomesic Pachic Haplustoll derived from Laird Sandstone (Soil Conservation Service 1967). The Sheridan Variant occurs on the south-facing slope overlooking White Gulch. It is a coarse-loamy, mixed isomesic Ustic Dystropedt derived from granite (Soil Conservation Service 1967).

Climate

The climate of the central California coast is characterized by: 1) year-round moderate temperatures; 2) summer fog and northwesterly winds; and 3) winter rains. The difference in mean monthly temperatures is only 6.5 C (Barbour et al. 1973) with September-October being the warmest months and January-February the coldest.

Temperatures in east-facing canyons on Tomales Point may be 7-8 C warmer than on exposed ocean bluffs at all months of the year. Winter storm patterns are often interspersed with periods of one to two weeks of temperatures above 15 C and calm winds.

Seasonal changes in the central California annual weather pattern are linked to development and movement of the North Pacific High (Weber 1981). During the summer, the North Pacific High dissipates, or deflects to the north, storms moving east from the western Pacific. Weakening or southerly movement of the high pressure system in the winter permits storms to move into central California. A seasonal low pressure area, the Great Valley Low, lies over California's Central Valley from late spring to early fall (Weber 1981). The gradient between the North Pacific High and Great Valley Low pressure systems is the "driving force for the movement of maritime air masses, fogs, and onshore winds to the continent," during the summer months (Weber 1981:66). Weakening of the gradient between the two highs in the fall coincides with the warmest months of the year along the central California coast.

Weather records for the Point Reyes area are limited.

Long term monthly precipitation records (since 1876) are available for the city of San Rafael (Crocker National Bank 1984); the U.S. Weather Bureau maintained a weather station at the Point Reyes Lighthouse between 1901 and 1942 (Weather Bureau 1942); residents have compiled monthly precipitation records (since 1926) for the community of Inverness on the Point Reyes Peninsula (D. Harney, pers. comm.). Weather records are available for Dillon Beach, across Tomales Bay from Tomales Point, between 1967 and 1970 (Smith and Obreski 1971). Mean annual precipitation at the Point Reyes Lighthouse was 45.7 cm (Weather Bureau 1942), while the mean for Inverness is 95.2 cm (D. Harney, pers. comm.). The mean annual precipitation at Dillon Beach for 1967-1970 was 63.2, 85.6, 69.8, and 69.6 cm, respectively (Smith and Obreski 1971). Annual precipitation at Dillon Beach is lower than Inverness for 1967-1970. Annual precipitation in Inverness for those four years (Fig. 2) is close to the long-term mean.

Thus, direct precipitation on the study area is likely lower than for Inverness. However, Tomales Point is often bathed in advective fogs from May through August. No measurements of precipitation from fog drip in non-forested areas of the central California coast were found. However, funnel gauges equipped with fog intercept screens 800 cm^2

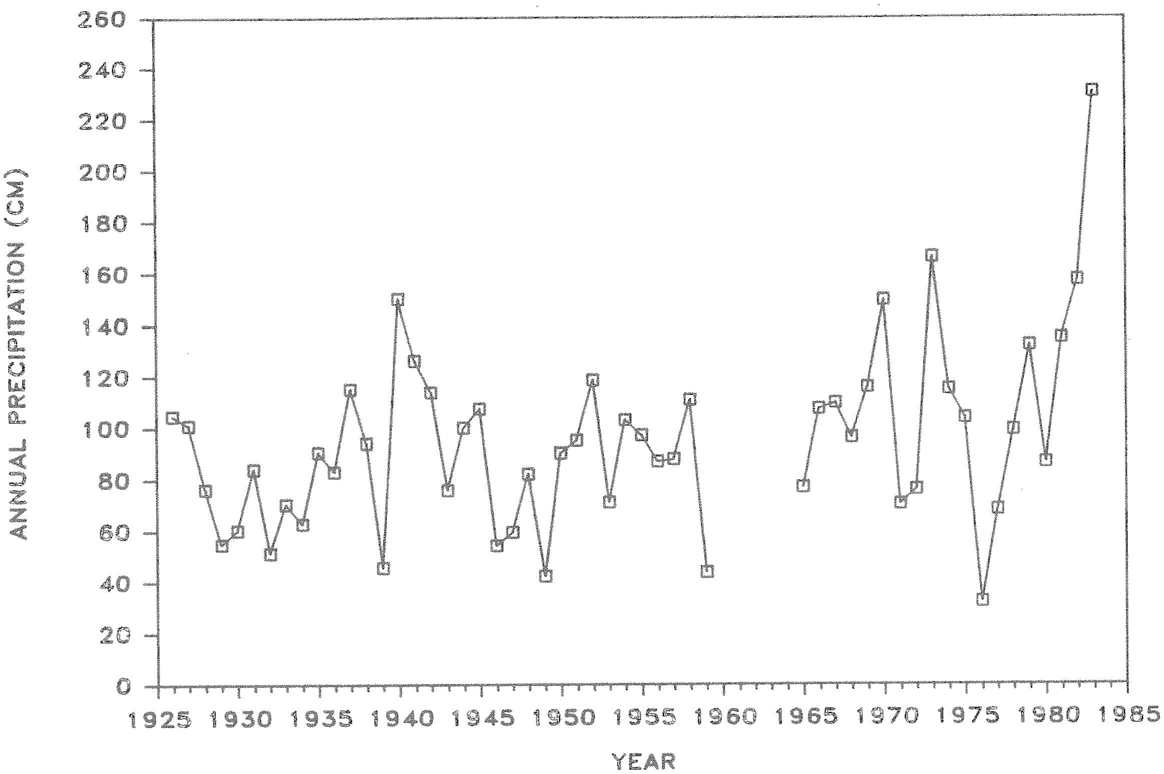


Figure 2. Annual precipitation pattern for Inverness, Marin Co., California 1926-1959; 1965-1983 (after D. Harney, pers. comm.).

in open grassland 22 km from the coast in Humboldt Co. measured an average fog drop of 30.4 cm between 19 June and 2 September 1971 (Azevedo and Morgan 1974). Many shrubs on Tomales Point are capable of collecting comparable amounts of advective fogs. Hence, total precipitation on Tomales Point, and other portions of the Point Reyes Peninsula, may be considerably higher than indicated by rainfall records. Also, there may be a considerable spatial variation in total precipitation determined by the distribution of vegetation intercepting advective fogs.

Monthly precipitation in San Rafael is highly correlated with monthly precipitation in Inverness ($Y = 0.3 + 0.99X$; $R^2 = 0.89$; $N = 642$). Annual precipitation records for San Rafael (Fig. 3) provide insight into long-term patterns. Annual precipitation has dropped below one-half the long-term mean on nine occasions between 1876 and 1983, including 1976 (Fig. 3). Hence, this degree of drought occurs approximately once every 12 years.

Climatic records from Dillon Beach for 1967-1970 (Smith and Obreski 1971) were used to develop a Thornthwaite diagram (Thornthwaite 1948) (Fig. 4). The calculations assume 125 mm of water available from soil storage based upon the mid-range of the effective root depth of Kehoe

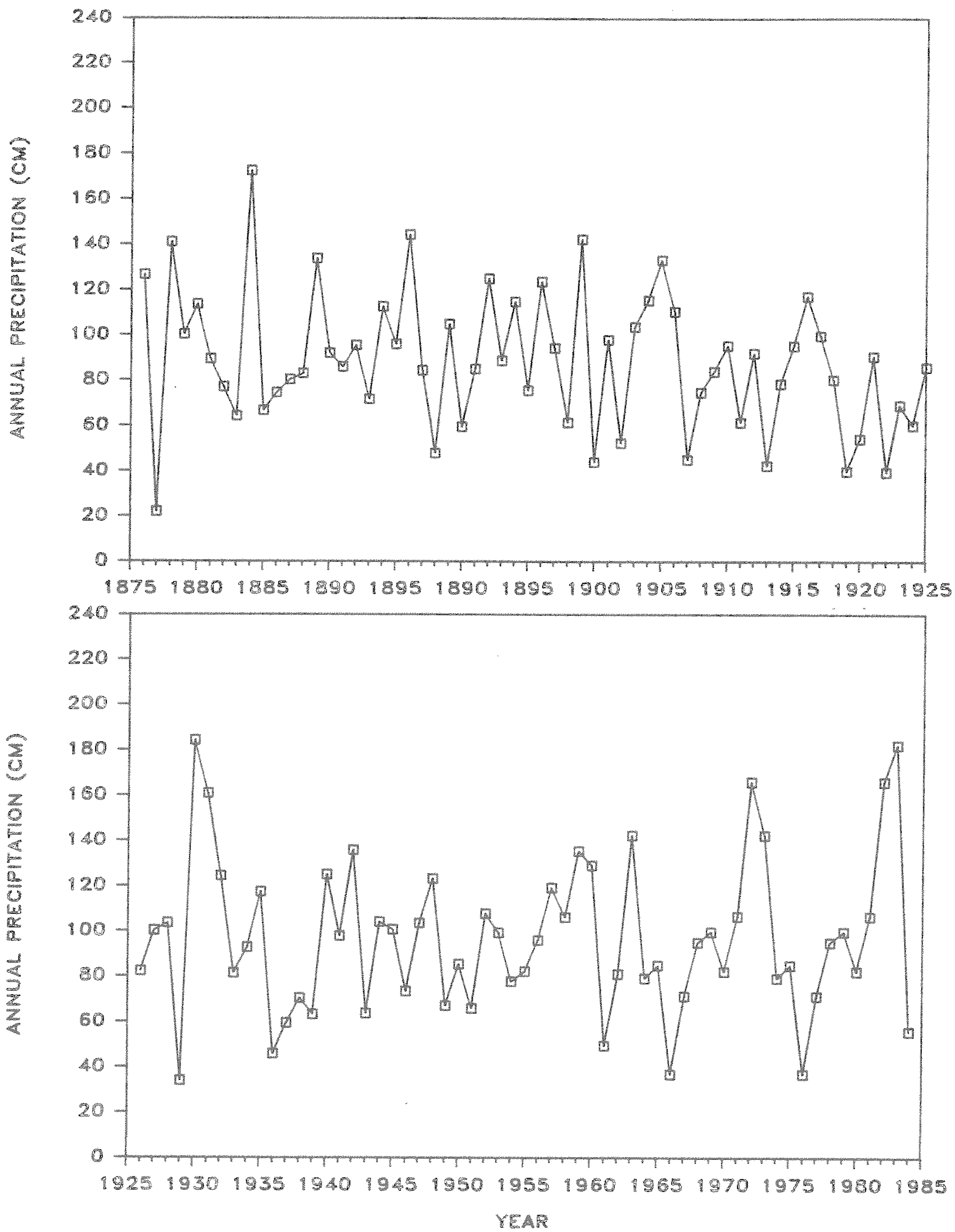


Figure 3. Annual precipitation pattern for San Rafael, Marin Co., California, 1876-1984 (after Crocker National Bank 1984).

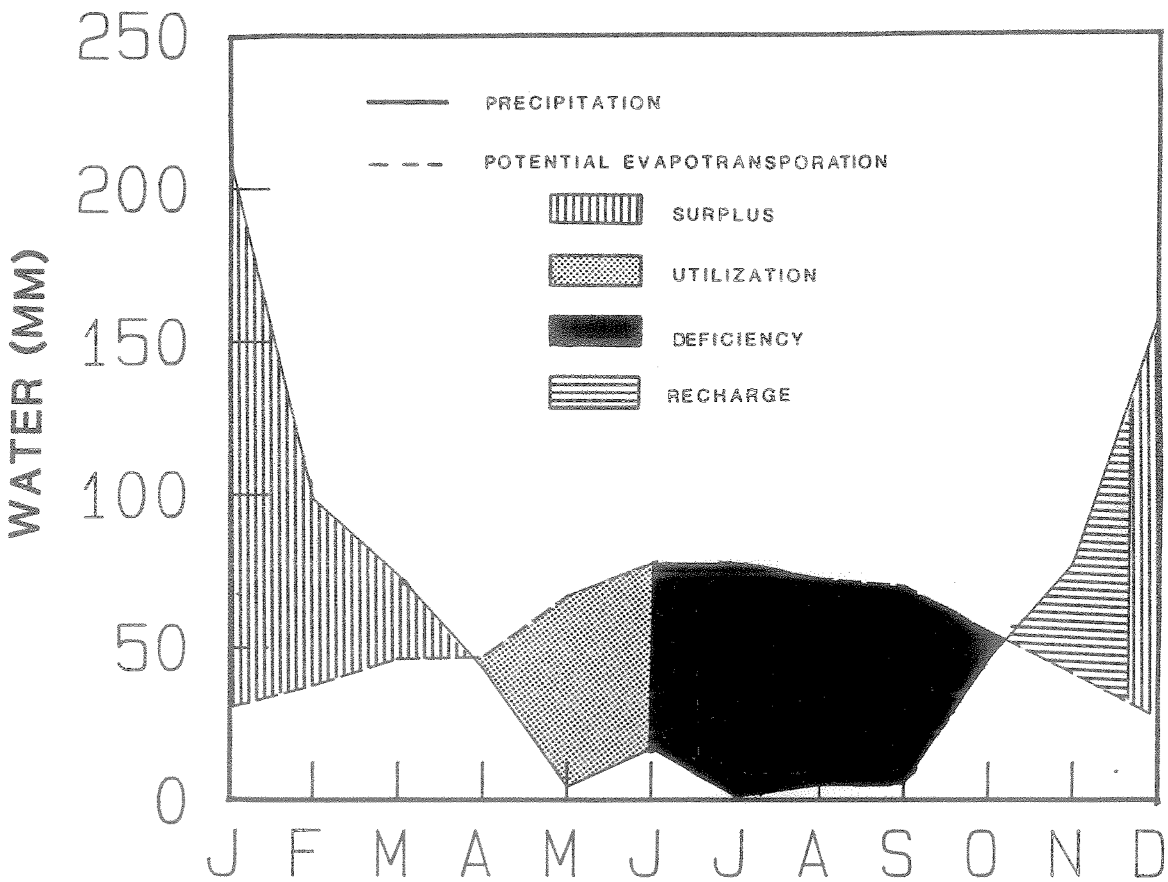


Figure 4. Monthly precipitation, evapotranspiration, and soil moisture regime for Tomales Point, Marin Co., California calculated by the method of Thornthwaite (1948).

Variant soil (Table 1). Monthly rainfall records for Inverness from January 1977 through December 1981 (Fig. 5) provide a reference for this study.

Past and Present Land Use

The pristine setting--The Point Reyes Peninsula supports a mosaic of coastal prairie and scrub common to much of the coastline of northern California (Kuchler 1977). The presence of sandy clay-loam surface soils with clay-loam to clay subsoil is typical of grasslands (Zumwalt 1972). The occurrence of endemic plant species suggests the type has existed for hundreds of years (Heady et al. 1977). Likely, the type developed under light grazing pressure with frequent fires (Heady et al. 1977). The earliest records of man in the central California region date back approximately 8,000 years (Fredrickson 1973). Indian burning practices certainly modified the distribution of vegetative types (Aschman 1959). Analyses of sediment samples suggest shifts in the proportion of grassland and scrub in pre-European times (Russell 1983).

In general, coastal prairie is characterized by the perennial California oatgrass (Danthonia californica), and the annual fescue (Festuca dertonensis), and (F. rubra),

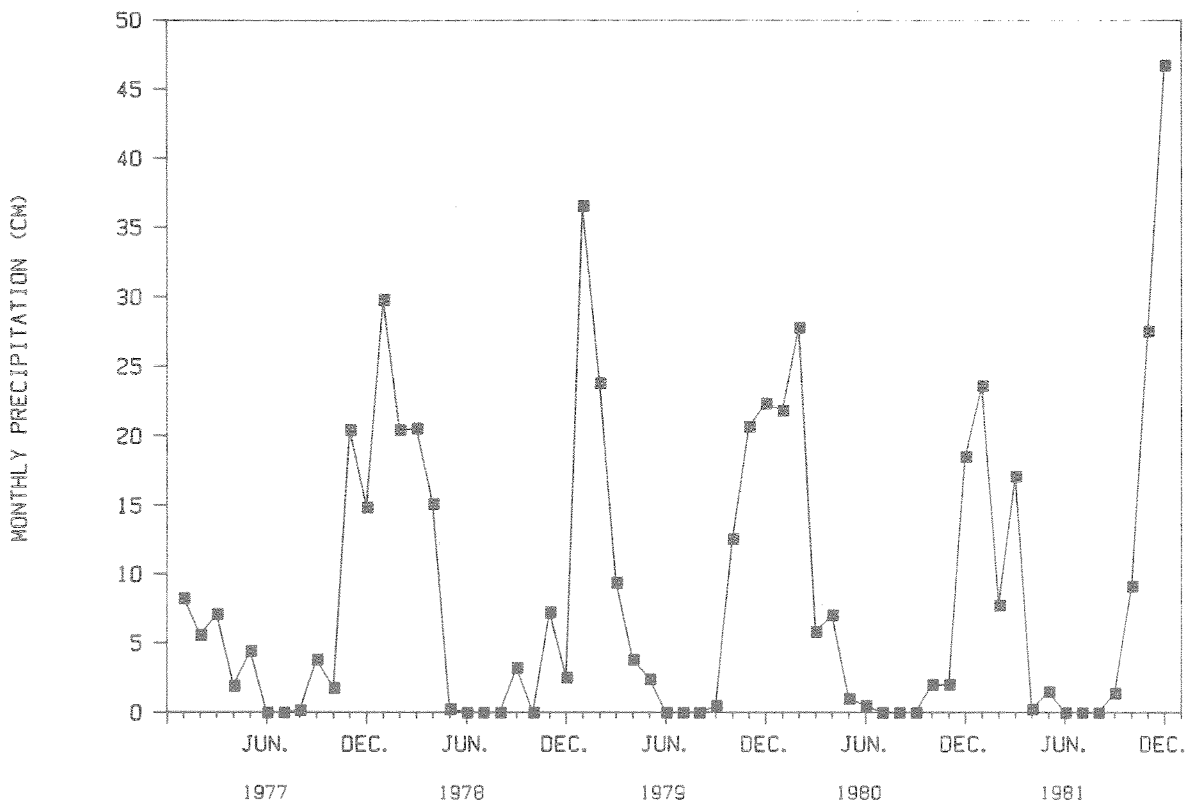


Figure 5. Monthly precipitation records for Inverness, Marin Co., California for January 1977 through December 1981 (after D. Harney, pers. comm.).

and the dicotyledons Douglas iris (Iris douglasiana), California buttercup (Ranunculus californicus), and blue-eyed grass (Sysyrinchum bellum) (Heady et al. 1977). The coastal prairie of Point Reyes Peninsula is somewhat atypical in that it is dominated by California brome (Bromus californicus), tufted hairgrass (Deschampsia caespitosa spp holciformis) and sheep sorrell (Rumex Acetosella) (Elliott and Wehausen 1974). Coastal scrub dominated by coyote bush (Bacharris pilularis) is more common on north-facing slopes (Heady et al. 1977). On those south-facing slopes where scrub occurs, its species composition is more diverse and includes California coffeeberry (Rhamnus californica), coast sagebrush (Artemisia californica), and poison oak (Rhus diversiloba) (Grams et al. 1977). A type of coastal scrub dominated by lupine (Lupinus spp.) forms a mosaic with the coastal prairie (Heady et al. 1977). Within this type, varied lupine (L. variicolor) is characteristic of more exposed sites along ocean bluffs, but is replaced by bush lupine (L. arboreus) away from the bluffs (Heady et al. 1977).

On Tomales Point, willow (Salix Hindsiana) occurs adjacent to springs and seeps, particularly at the mouths of streams flowing into Tomales Bay (Lathrop and Gogan 1985). Alder (Alnus sp.) forms the dominant species in a

riparian woodland along the stream flowing into Tomales Bay just north of Pelican Point. This stream was the only source of drinking water for domestic stock on Tomales Point during the 1976-1977 drought (M. McDonald, pers. comm.).

The region supported tule elk (Cervus elaphus nannodes) (McCullough 1969), Columbian black-tailed deer (Odocoileus hemionus columbianus) (Longhurst et al. 1952), grizzly bear (Ursus arctos) (Van Atta 1946), mountain lion (Felis concolor), and coyote (Canis latrans). Large avian predators included golden eagles (Aquila chrysaetos) and bald eagles (Haliaeetus leucoceahalus).

The earliest account of the central California coast comes from the crew of the Golden Hinde in June 1579. However, the precise site of their landing is too obscure to suggest the area they describe is the Point Reyes Peninsula. The first description of the Peninsula came from the Spanish crew of the San Augústin which sank in Drakes Bay in December 1595. Accounts from crew members confirm the presence of elk in the area as they relate they, " ... saw deer walking about, the largest ever found, as could be seen by their antlers ..." (Wagner 1924:14) and "there were a great quantity of deer horns, one of which

... showed sixteen palms from point to point." (Wagner 1924:23).

There is a gap of almost 200 years before another explorer described the Point Reyes Peninsula. In August 1793, a Spanish lieutenant named De Goyoechea led a contingent of soldiers onto the Peninsula and to the tip of Tomales Point (Wagner 1931). On his return, they climbed Mount Vision. In describing the Peninsula De Goyoechea wrote, " ... I found a peninsula where there is a very fine site but a distance from firewood and timber. There are many deer there, some very good pasture and springs in all parts, very appropriate for raising cattle of all kinds and very extensive." (Wagner 1931:343). Unfortunately, it is not possible to know whether De Goyochea referred to black-tailed deer, elk, or both.

A second party put ashore on Tomales Point in October 1793. Menzies' account suggests a coastal prairie-scrub mosaic and confirms the occurrence of fire. "The grass and brush wood had been lately burned down so that I had little opportunity to augment my collection ..." (Eastwood 1924:302).

<u>Hide and Tallow Industry</u>--The Mexican administration of

Alta California ceded the lands of the Point Reyes Peninsula to private ownership between 1836 and 1843, most of the Indian population having been removed to Mission San Rafael by 1820 (Mason 1970). Longhorn cattle, sheep and horses were introduced to the Peninsula. Cattle stocking rates were high. Simpson (1847:274) described the Peninsula from Drakes Bay in December 1841, as a " ... level sward of about a mile in depth, backed by a high ridge of grassy slopes -- the whole pastured by numerous herds of cattle and horses ...".

The most complete description of range conditions at Point Reyes and elk prior to their extirpation comes from Revere's (1947) description of an elk hunt in August 1846. Revere noted that proximity to the ocean and advective fogs favored a luxuriant growth of grasses. The Mexicans were aware that August was the best time to take elk as it is when they are at their fattest (presumably referring to males just prior to the rut). A herd of over 400 elk was sighted. Revere's observations suggest the slaughter of elk was extensive, "The Punta Reyes is a favorite hunting ground, the elk being attracted by the superior quality of the pasture -- the land lying so near the sea, that the dews are heavy and constant, adding great luxuriance to the wild oats and other grains and grasses. The elk are very

abundant at this season, and more easily killed than cattle. We passed many places, on our way back, where mouldering horns and bones attested to the wholesale slaughter which had been made in previous years by the rancheros of the neighborhood." (Revere 1947:68).

A Mr. P. J. Shafter related an account of a later elk hunt near Limantour Estero, " ... in about 1850 a Spanish priest with a band of Indians went over to Point Reyes and drove a herd of about seventy-five elk on to a peninsula in Limantour Bay. The priest had them nearly all killed for their hides and tallow -- bulls, cows and calves, the last elk of Marin County." (Evermann 1915:90). Shafter also related that he was, " ... told by Frank Miller, an old hunter and trapper, that in 1852 he ... had seen over a hundred elk swim across Tomales Bay and go north toward Mendocino County." (Evermann 1915:90). Shafter came to Marin County in 1862 and believed all elk were gone from the Point Reyes Peninsula at that time (Evermann 1915). An independent account suggests the few survivors may have been taken as late as 1862. Between 1857 and 1862, the Steele brothers supplied dairy products from Point Reyes Peninsula to San Francisco and, "If the steamer at Point Reyes did not have a full load, the 'boys' went out and got enough elk to fill the boat." (Steele 1941:264).

A Mr. C. Allen came to Marin County in 1872. He noted, "In his earlier years he found elk antlers very plentiful about Point Reyes from Bolinas north to the mouth of Tomales Bay." (Evermann 1915:90). Thus, elk were once common in herds of 100+ on the Point Reyes Peninsula. Likely, such large herds were not resident in any area year-round, but undertook seasonal shifts in distribution. Grizzly bear numbers were also reduced in this period. They too were eliminated completely sometime after the 1860's (Van Atta 1946).

Extensive year-round grazing by domestic stock modified the rangeland's botanical composition and in particular reduced the abundance of native perennial grasses (Zumwalt 1972). The first annual species to expand into overgrazed areas were probably the native annual hairgrass (Aira danthoides) and foxtail fescue (Festuca megalura). Several exotic plant species became established in this period.

The hide and tallow industry came to a close in the early 1850's as a result of the flood of immigrants to California following the discovery of gold. Livestock products were in high demand for consumption in San Francisco and elsewhere (Toogood 1980). By 1854, the two Mexican land grants on the Point Reyes Peninsula had been

combined under the ownership of a single American, O. L. Shafter (Mason 1970). Tax records for that year give some idea of the rapid growth of livestock numbers and stocking rates at the close of this period. The 14,380 ha Rancho Punta de los Reyes supported 400 wild horses, 400 "tame" cattle, 3,500 "wild" cattle, and 1,000 sheep and goats (Toogood 1980:71).

The Dairy and Beef Industry--An area approximating the present tule elk range was purchased as a dairy ranch by S. Pierce in December 1858, while much of the remainder of the Peninsula was leased to tenant ranchers (Mason 1970). A year later, 160 ha of Tomales Point had been cleared and the ranch stocked with 37 milk cows, 40 other cattle and 24 hogs (Toogood 1980:169).

By 1870, the ranch was stocked with 250 dairy cows, 220 other cattle (0.5 cows/ha) and 100 hogs, and cleared fields produced 68,000 kg of hay and 1,000 bushels of potatoes (Toogood 1980:171). Likely, it was during this period that the earthen dams on many streams and creeks were built to make stock ponds. Plowing was done in a downhill direction (Zumwalt 1972). Failure to harvest potatoes, smooth the furrows and plant wheat before the first heavy rains turned the furrows into gullys (Zumwalt 1972). Large amounts of

topsoil washed into Tomales Bay from potato fields on both sides of the Tomales Bay (Zumwalt 1972).

In November 1862, H. Brewer crossed Tomales Bay and landed on Tomales Point, probably near White Gulch, and proceeded south (Farquhar 1966). Brewer described the area, "The point is a long ridge which rises to the south, where it forms mountains, cut by deep canyons, and covered with an almost impenetrable chaparral ... the chaparral peaks are only a small part of the whole, the rest is mostly fine pasturage." (Farquhar 1966:349).

The Pierce Point Ranch's high level of productivity continued. In 1878-1879, the ranch was stocked with 300 dairy cows, 150 replacement stock, and 200 hogs. However, by the 1890's the high quality native perennial grasses were all but eliminated by trampling and year-round grazing. The ranch's productivity declined and supplemental feeding became a necessity (Sugnet and Bartolome 1983).

Predator control was practiced extensively in this period. Mountain lion were greatly reduced in numbers and were possibly absent from the early 1930's through the early 1970's. Coyote were eliminated in the 1940's (Clark

1982) leaving only bobcats (Lynx rufus) and gray fox (Urcyon cinereoargenteus) as the largest mammalian predators.

Exotic ungulate species were also introduced to Point Reyes. In the 1940's, populations of axis deer (Axis axis) and fallow deer (Dama dama) were established (Wehausen and Elliott 1982). Rocky Mountain elk (C. e. nelsoni) were introduced at this time but destroyed before they had an opportunity to reproduce (Mason 1976).

The dairying era continued until after 1945, when dairying and hay raising operations were phased out at the Pierce Point ranch in favor of a beef cattle operation (National Park Service 1981). Livestock stocking rates on the Point Reyes Peninsula doubled between 1960 and 1980 (L. Britten, pers. comm.).

A number of exotic plant species became dominant in the vegetation in this era (Zumwalt 1972). Introduced grasses include slender oat (Avena barbata), soft chess (Bromus mollis), Australian chess (B. arenarius), and ripgut (B. rigidus). Prominent forbs introduced include red-stemmed filaree (Erodium cicutarium) and English plantain (Plantago lanceolata).

<u>The Conservation Era</u>--A National Seashore embracing much of the Point Reyes Peninsula was authorized in 1962 and officially established in 1972 (National Park Service 1978b). The Pierce Point dairy on Tomales Point was purchased by the National Park Service in 1973 (National Park Service 1981). Livestock operations continued through October 1979. All but a limited area of Tomales Point was designated as wilderness in 1976, the exception being a corridor providing access by automobile to the upper Pierce Ranch and McClure's Beach parking lot (Fig. 6) (National Park Service 1978b). A historical zone including portions of the corridor and wilderness zone was established in 1981 (Fig. 6) (National Park Service 1981).

In 1976, the United States Congress declared restoration and conservation of a tule elk population in California of at least 2,000 an appropriate national goal and instructed the Secretary of the Interior to make land under the Department's jurisdiction available to tule elk reintroduction. Point Reyes National Seashore was identified as a potential site for translocation in the joint resolution. In response to this mandate, the Tomales Point portion of the Seashore was identified as a potential release site for tule elk the same year (National Park Service 1976). Tule elk were translocated to the area in 1978.

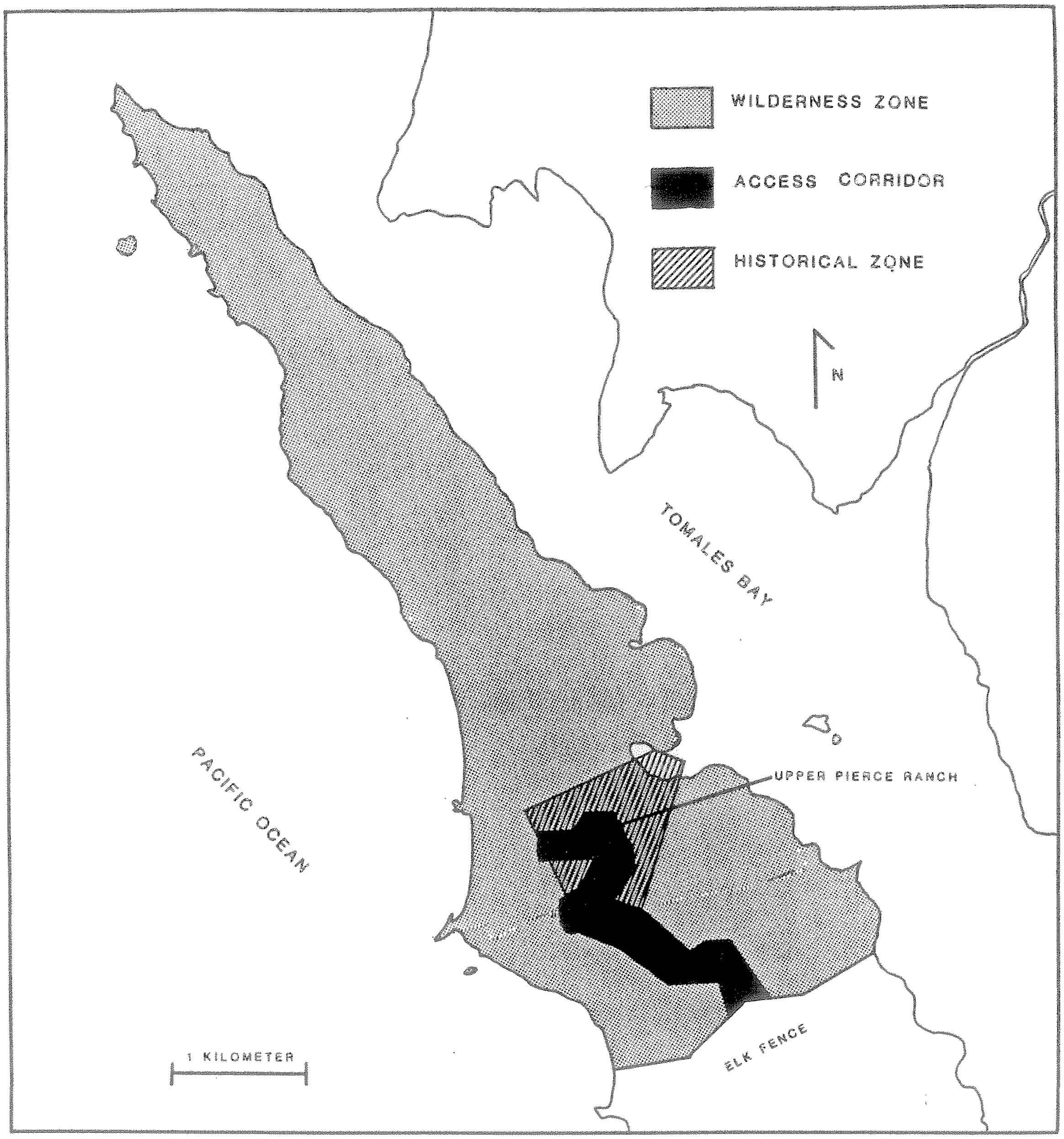


Figure 6. Land management designation on Tomales Point, Point Reyes National Seashore, Marin Co. (after National Park Service 1978b, 1981).

CHAPTER III

BOTANICAL COMPOSITION AND PRODUCTIVITY

Estimates of botanical composition of habitats at Tomales Point were obtained to assess the degree of dietary selection by tule elk and deer. Productivity of herbaceous plants and shrubs was determined to calculate the range's carrying capacity for ungulates. Composition and productivity provide baseline data against which to measure future vegetational changes triggered by the elimination of livestock grazing by changes in deer and elk numbers or by prescribed burning.

METHODS

A one kilometer square Universal Transmercator (UTM) grid of Tomales Point was further subdivided into 4-ha cells and each numbered consecutively (Fig. 7). Cells were categorized as to aspect (north, level, south) and vegetative type (Table 2). The range was stratified into two approximately equal north and south sections representing areas utilized and not utilized by elk at the onset of the study. Eighteen sample sites were selected in each section for a total of 36 cells. Permanent photographic stations and plots for sampling botanical

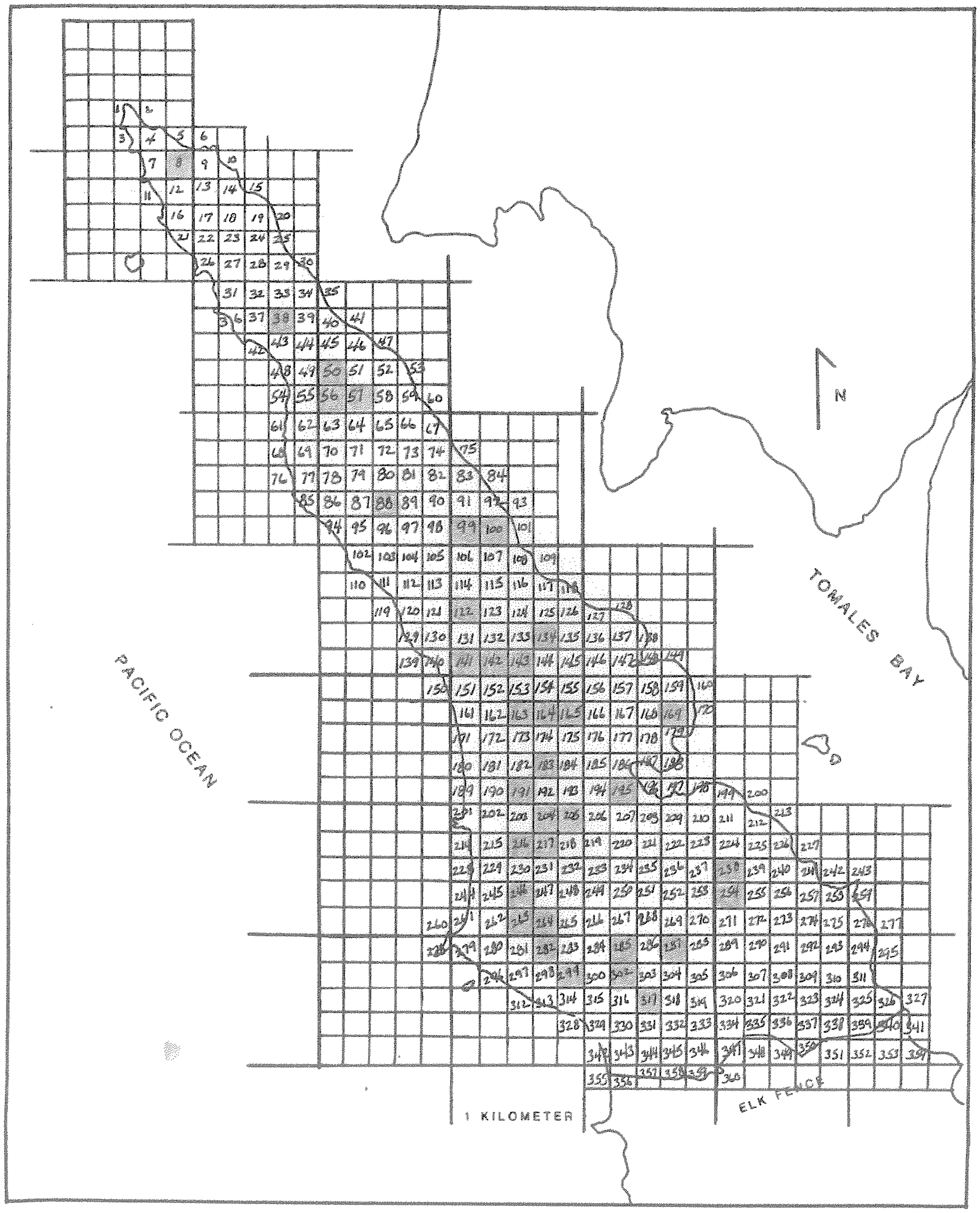


Figure 7. Subdivision of Universal Transverse Mercator (UTM) grid of Tomales Point into 4-ha cells.

Table 2. Categories and descriptions of vegetative types on Tomales Point.

Vegetative Type	Description
No Vegetation	Beaches and steep cliffs with less than 10% plant cover.
Open Grassland	Areas with extensive herbaceous plant cover and with shrub cover of less than 30%.
Lupine Grassland	Areas with moderate herbaceous cover and with a shrub cover of between 30 and 60% predominantly of <u>Lupinus arboreus</u>.
Baccharis Grassland	Areas with moderate herbaceous cover and with shrub cover of between 30 and 60% consisting predominantly of <u>Baccharis pilularis</u>.
Thick Scrub	Areas with little herbaceous cover and shrub cover greater than 60% consisting predominantly of <u>B. pilularis</u>.

composition were established in each sample cell. Herbaceous and shrub productivity measurements were made in half the sample cells in each stratum. Cells were selected using a table of random numbers. Three herbaceous and shrub productivity plots were assigned to each aspect. Cells were selected without regard to vegetative type except that herbaceous productivity samples were not located in the thick scrub type and shrub productivity exclosures were not placed in open grassland. The center of each cell was marked with a brass survey marker to facilitate relocating for long-term monitoring.

Vegetation Change: Photographic Stations

Permanent photographic stations were established over each of the 36 survey markers. A tripod mounted camera was set at a standard height of 1.4 m above the ground and the horizontal angle of the camera set to include fore-, middle and background in each image when possible. Photos (35 mm slides) were taken at each station in the four cardinal directions (true azimuths 0, 90, 180, 270). Photographs were taken in October 1979, February, June and October 1980 and February and June 1981 as part of this study. Photos have been taken annually during September and October from 1982 onward by National Park Service personnel. All photos

are on file at Point Reyes National Seashore.

Canopy Cover and Botanical Composition

Canopy cover and botanical composition were determined in June-July 1980 and May-June 1981 with most sampling done in June of both years. Two transects each oriented east-west and north-south, were centered on each of the 36 survey markers. Intercept sampling points along each transect were determined using the step-point method (Evans and Love 1956); points were located a pace apart and totaled 100 per transect. All contacts were recorded for each pin. Variables recorded included bare ground, plant litter, or plant taxa. the total number of hits on plant material was taken as a measure of canopy cover. All shrubs encountered on line transects were measured for height, maximum crown width and a second measure of crown width taken perpendicular through the shrub center. The product of these values and pi provides an estimate of crown volume. The shrub was then quartered and the total number of live twigs in a randomly selected quarter tallied.

Plants not identified in the field were collected and keyed. If necessary, identification was confirmed by comparison with herbarium specimens at Point Reyes National Seashore or the Jepson Herbarium, University of California, Berkeley. Species were characterized to plant type as: 1) lower plants; 2) forbs; 3) grasses/sedges; 4) shrubs; 5) trees; or 6) unknown. In the case of all plant types except shrubs and trees species were also characterized to growth form as: 1) perennial; 2) annual/biennial; or 3) unknown.

Herbaceous Productivity and Utilization

Eighteen 6.25 ha cells selected for herbaceous productivity sampling were subdivided into quadrants through the center marker. A quadrant within each cell was selected with a random numbers table. Three pyramid shaped, hog-wire exclosures of 2.25 m^2 (Frischknecht and Conrad 1965) were set in the selected quadrant at an angle of 22.5° from each other as measured from the center marker. The middle exclosure was placed 75 paces, and the two lateral exclosures were placed 45 paces, from the center marker (Fig. 8). The aerial portion of all herbaceous vegetation was clipped outside each newly established exclosure within a 0.093 m^2 (1 ft^2) wire

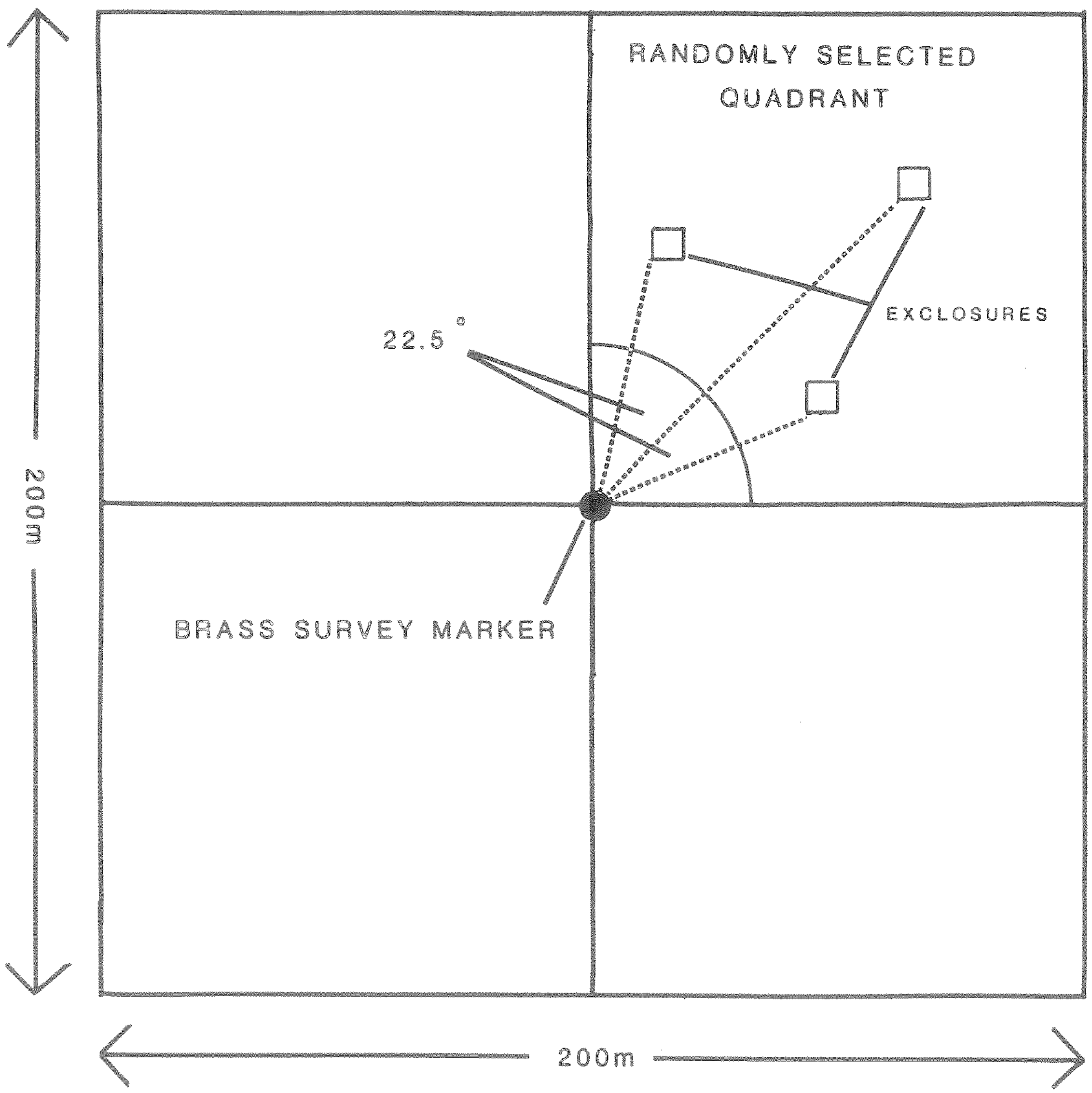


Figure 8. Diagram of establishment of hogwire exclosures within the randomly selected quadrant of a 4-ha sample unit.

frame using hand clippers with the blades held flush to the ground. Nine sets of exclosures were established in December 1979 and the remaining nine in February and March 1980. Herbaceous vegetation was clipped inside and outside each exclosure from the plot establishment through June 1981. Sample periods approximated: 1) the end of the wet season (February 1980, 1981); 2) early dry season (June 1980, 1981); and 3) late dry season (October 1980). In each sampling interval, the exclosures were relocated 2 m further away from the center survey marker. The sampling regime was modified somewhat in October 1980. One of each trio of exclosures was randomly selected and a fine meshed wire secured to the exclosure perimeter 0.3 m below and above the soil surface to exclude grassland rodents. Herbaceous vegetation within these exclosures was not clipped until June 1981.

Productivity of herbaceous cover was calculated as the difference between standing crop outside the exclosure at one time interval (t_i) and inside the exclosure at a later time interval (t_{i+1}) (National Research Council 1962). Herbaceous cover utilization was calculated as the difference in standing crop inside and outside each exclosure at the same time interval (National Research Council 1962).

Shrub Productivity and Utilization

Eighteen paired plots, nine in the north section and nine in the south, were established in randomly selected cells as described above. Plots were selected without regard to vegetative types except that none were located in the open grassland type. Stands of shrubs judged representative of the cell were selected for paired sampling plots to represent sites unutilized and utilized by large herbivores. Unutilized plots were protected by exclosures (3m x 3m) manufactured from hog-wire (3m high) and supported in each corner with pieter poles. Utilized plots (3m x 3m) were marked in each corner with sections of angle iron.

In each plot, 20 twigs were tagged 10cm below the growing tip. Exclosures were constructed and twigs tagged in February 1980. They were sampled and new twigs tagged in June 1980 and sampled again in June 1981. To determine plant growth twigs were clipped 10 cm above each tag. The clipped material was packed loosely in a paper bag and dried in a drying oven at 18.3 C 6-7 days before weighing. The number of lateral twigs on twigs from each plot were tallied and productivity was expressed as the weight of dry matter per lateral twig. Productivity per shrub was

calculated as the product of dry matter per twig and mean number of lateral twigs per shrub for each shrub species and each vegetative type as determined from line transects. Shrub productivity was calculated as the additional biomass present on shrubs inside exclosures at sample period t_{i+1}. Utilization was calculated as the difference in biomass between inside and outside each set of paired plots in the same time period (National Research Council 1962).

RESULTS

Vegetative Types

Examination of the distribution of vegetative types reveals more lupine grassland and open grassland to the western side of the study area and more thick scrub to the eastern side, particularly the southeast (Fig. 9). Vegetative types probably reflect a variety of environmental parameters including, but not limited to, slope, aspect, distance from the ocean, soil type and previous land-use practice. These types appear to adequately describe vegetation and provide a suitable stratification for inventory of composition and productivity. Comparison on the proportion of vegetative

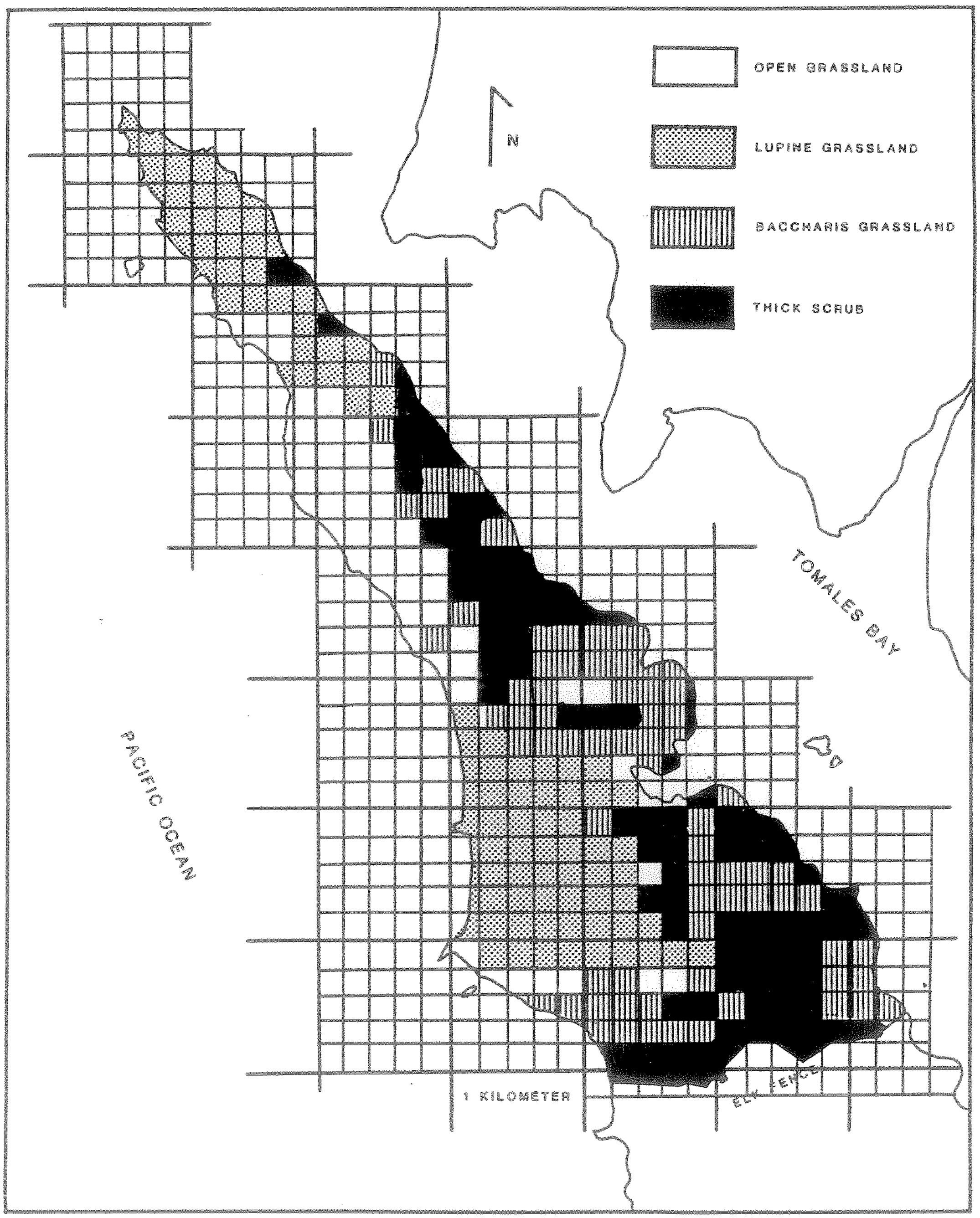


Figure 9. The distribution of four main vegetative types on Tomales Point.

types available and sampled (Fig. 10) shows the three grassland types are over-represented in samples while the scrub type is correspondingly under-represented. As a result of unequal sample sizes, all analyses of species composition are based upon percent relative abundance rather than absolute abundance.

Vegetation Change: Photographic Stations

A sample of photos of four locations (Fig. 11) on Tomales Point was selected from the series of slides as representing vegetative trends described in this report and by Lathrop and Gogan (1985). Conditions illustrated include an open grassland site with little evident change (Fig. 12), a baccharis grassland unchanged (Fig. 13), the demise of a stand of bush lupine (Fig. 14), and invasion of grassland by coyote bush (Fig. 15). Vegetation, particularly lupine cover, appears to have changed considerably on Tomales Point between 1979 and 1984.

Canopy Cover and Botanical Composition

A total of 11,083 and 17,916 intercept points were recorded in 1980 and 1981, respectively. Grasses were the predominant plant cover in the three grassland types for

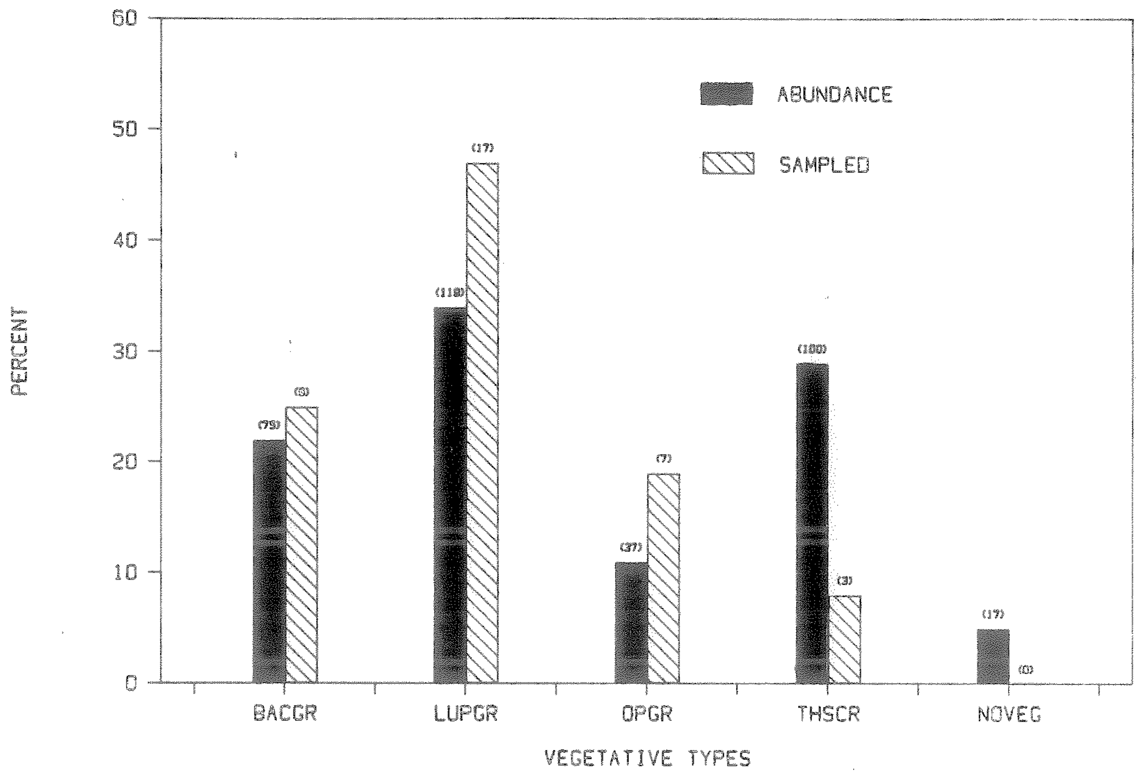


Figure 10. The percent of vegetative types available and sampled on Tomales Point. Number of 4-ha cells given in parentheses.

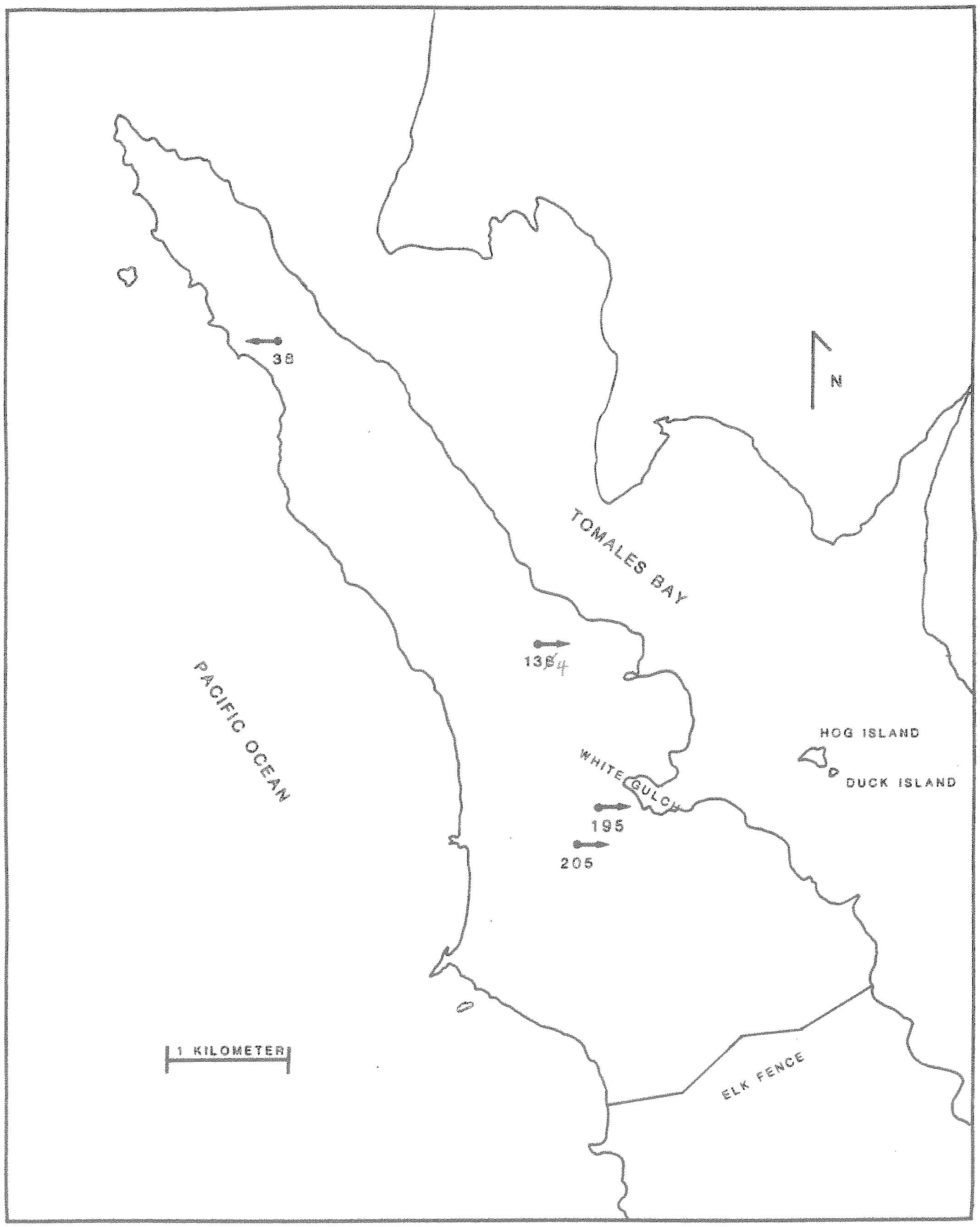
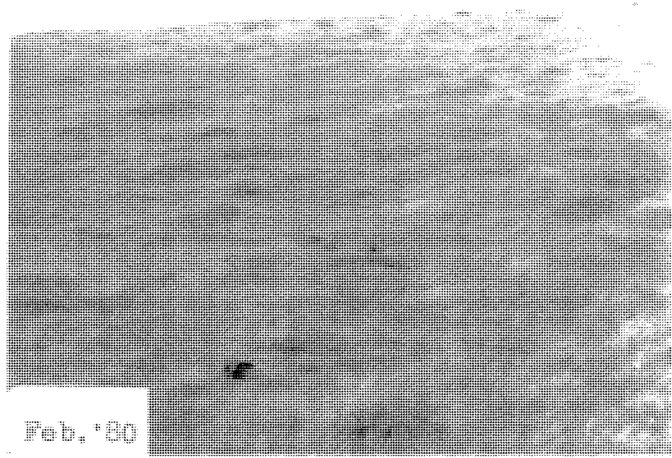


Figure 11. Location and direction of photographic stations used to illustrate vegetative trends.



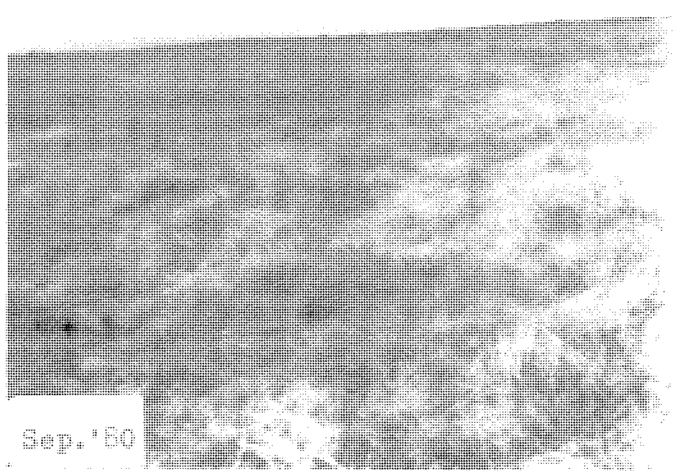
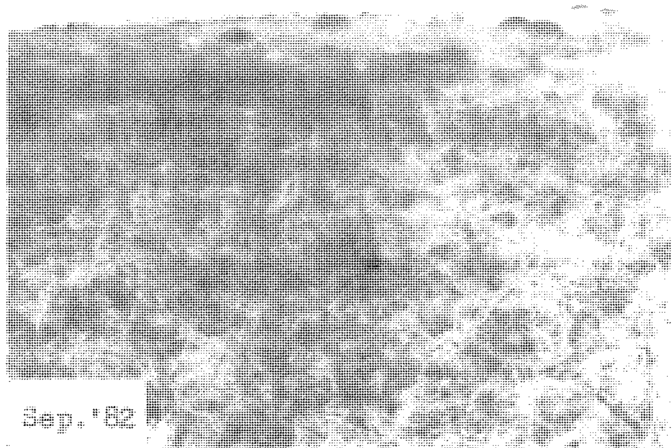
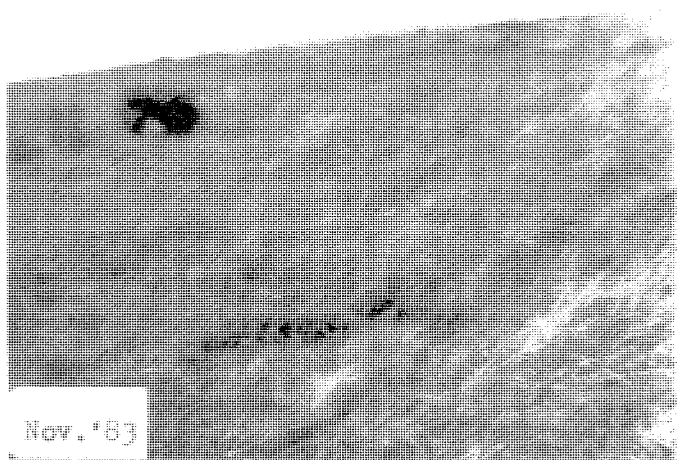


Figure 12. View from center of cell 38 west toward the Pacific Ocean. The foreground shows no change. The middle and background show slight increase in bush lupine and sedge. Large sedge in middle ground of the 1983 picture is due to slightly different orientation of camera. Dominant species in the foreground include fescue, Italian ryegrass, and soft chess.





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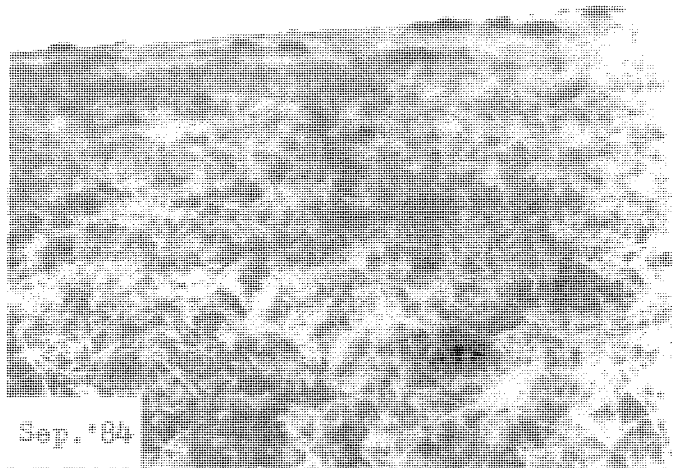

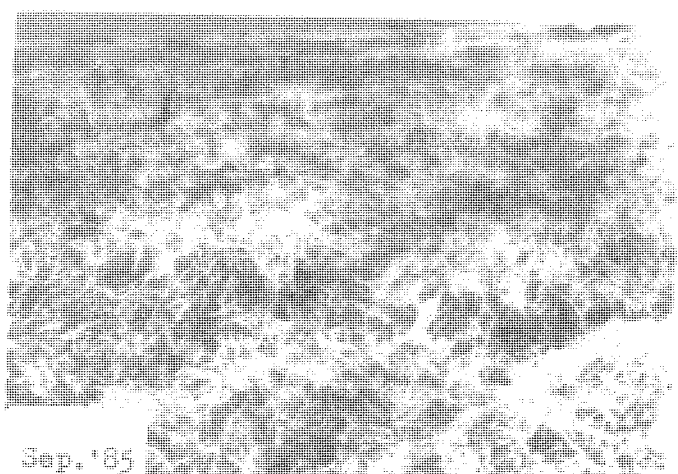

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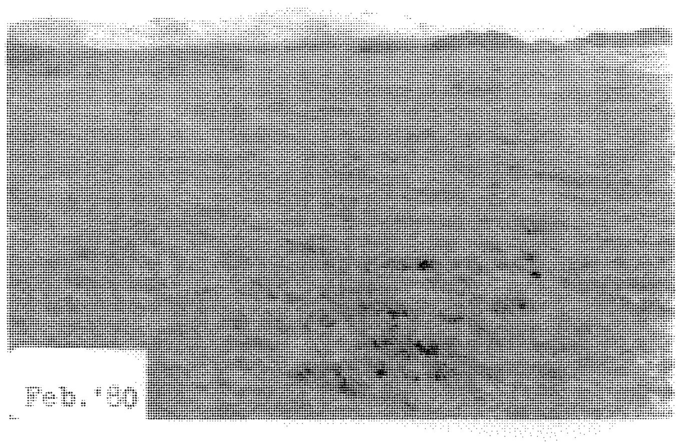


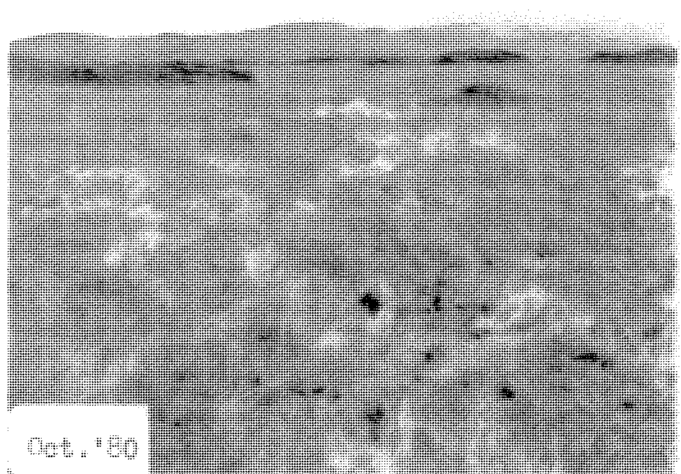
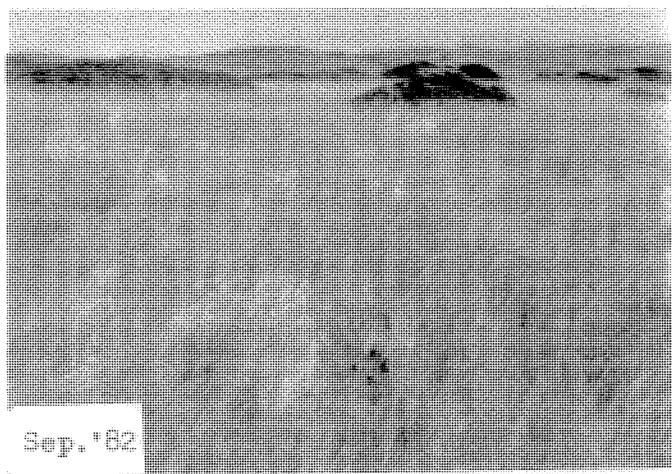
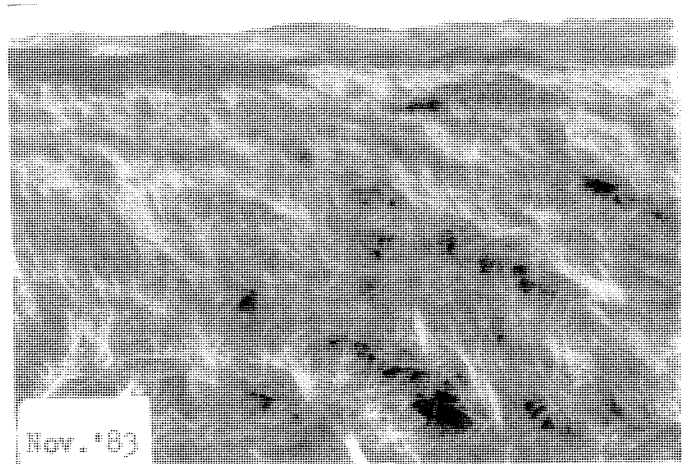


Figure 13. View from center of cell 134 east toward Bolinas Ridge. The middle ground shows growth of existing coyote bushes but no establishment of new plants. The foreground shows no establishment of coyote bush. Dominant species in the foreground are silver hairgrass, soft chess, perennial ryegrass and English plantain.





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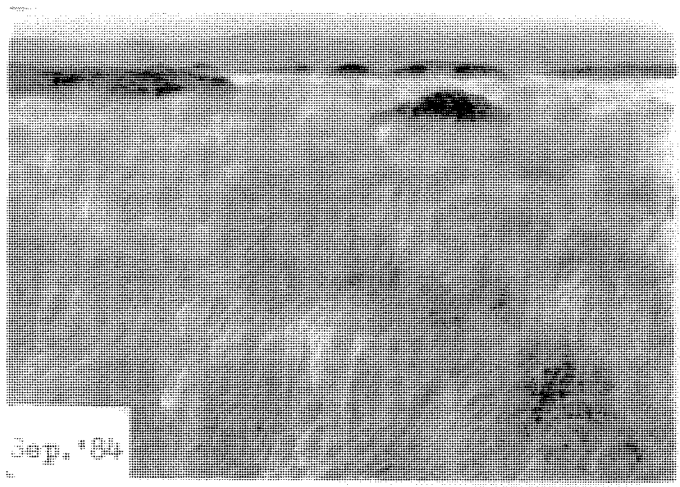

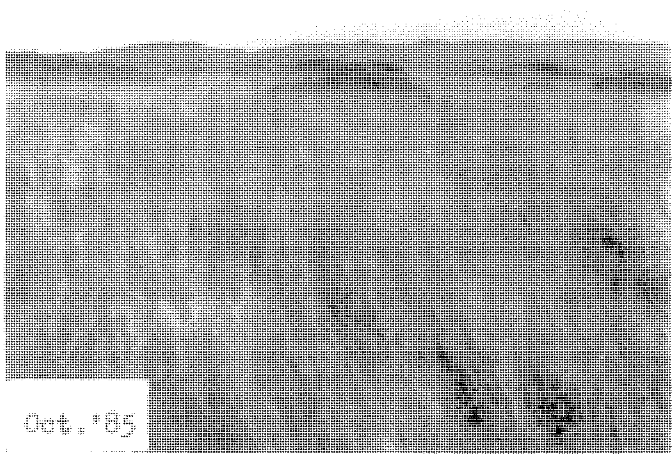

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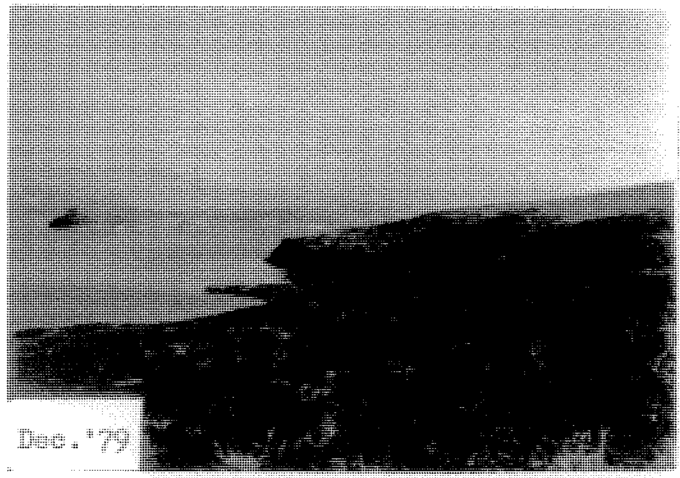


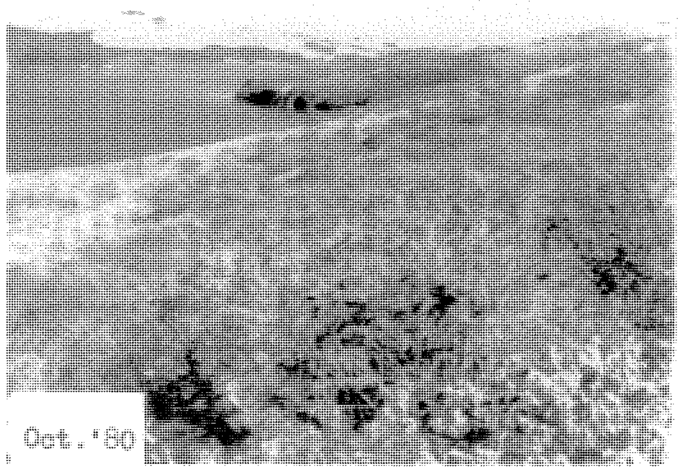
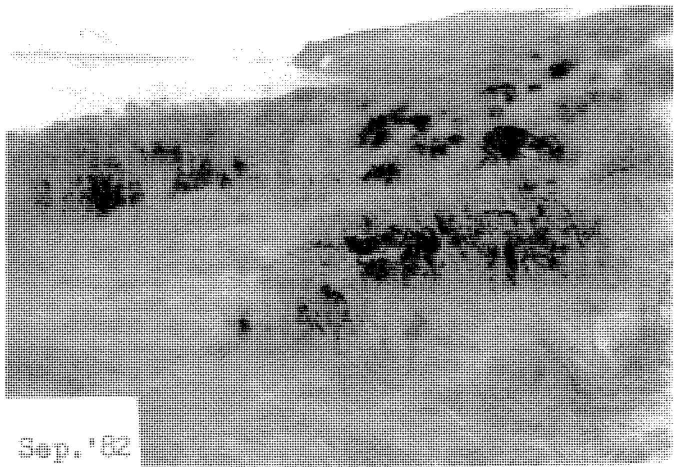


Figure 14. View from center of cell 195 east toward Bolinas Ridge across Tomales Bay at White Gulch. Hog and Duck Islands are visible in the middle of Tomales Bay. The extent of mud flats visible in White Gulch in middle ground varies with tidal conditions. The foreground shows an extensive stand of bush lupine in 1979 was considerably thinned by 1982 and gone by 1984. The middle ground shows no change in a stand of thick scrub divided by an old ranching road. Dominant species in the foreground include soft chess, perennial ryegrass and ripgut grass.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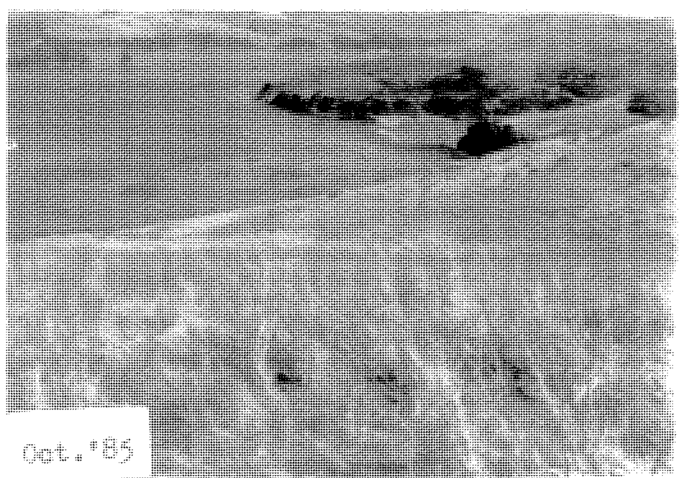

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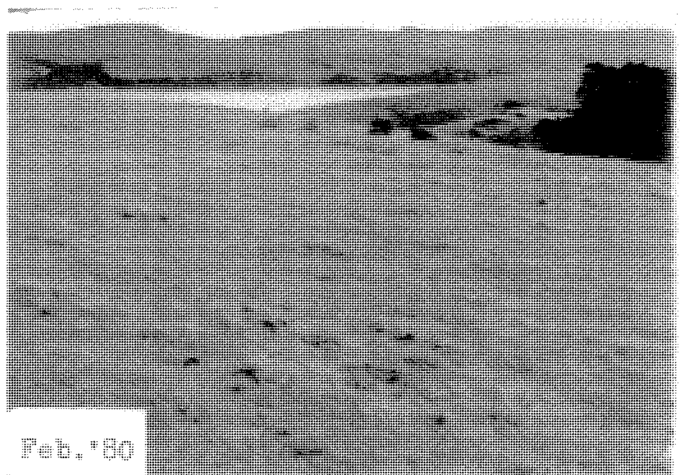

Figure 15. View from center of cell 205 east toward Bolinas Ridge across Tomales Bay. Introduced Monterey cypress in the middle ground are at the northeast corner of Upper Pierce Ranch. Fore- and middle ground show an invasion of coyote bush into open grassland. Dominant species in the foreground include soft chess, perennial ryegrass and English plantain.

Figure 15. Continued.

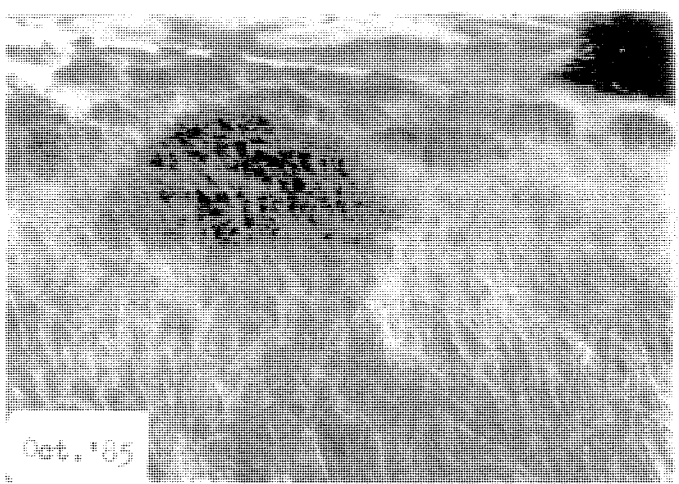

Figure 15. Continued.

both years (Fig. 16). Forbs formed a greater portion of the plant cover in 1981 than 1980 with the most striking difference in thick scrub. Shrubs are more abundant in the thick scrub type than in any other vegetative type. Transect data indicated little measurable difference in the percent cover of shrubs between the lupine grassland and open grassland types although these types were differentiated initially in vegetative mapping on the proportion of shrub cover present.

More species of perennial than annual/biennial forbs and grasses occurred in all vegetative types in both years (Table 3). An overall increase in the number of species recorded in 1981 compared to 1980 is most pronounced in annual/biennial and perennial forbs.

The abundance of plant species was categorized on the basis of relative cover (total number of canopy hits in each vegetative type) as: 1) uncommon -- less than one percent; 2) moderately common -- greater than one but less than five percent; and 3) dominant -- five percent or more. The increase in total number of plant species encountered from 1980 to 1981 is largely attributable to an increase in species in the "uncommon" class (Fig. 17). However, there was a concurrent increase in the number of

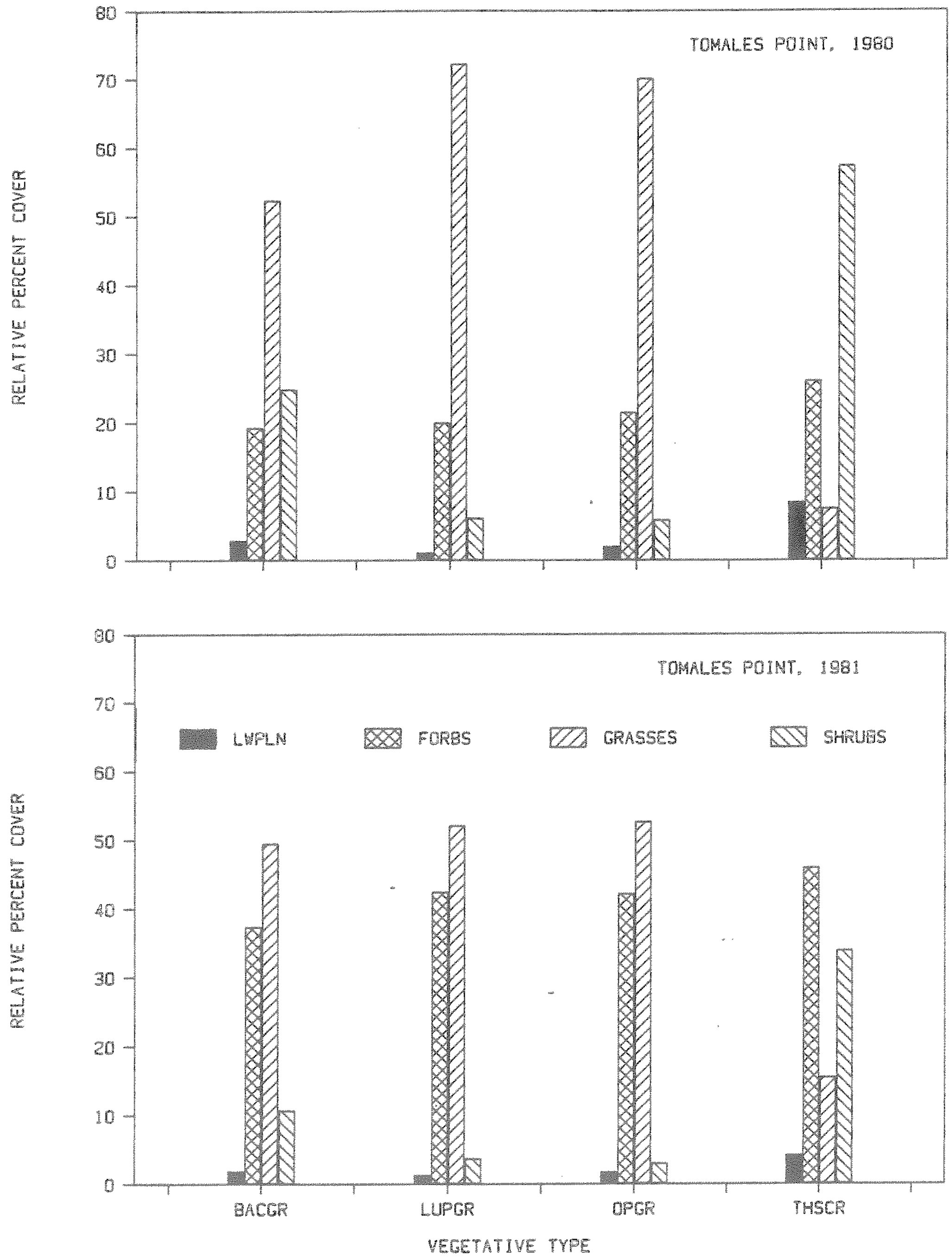

Figure 16. Percent relative ground cover by plant types for the four vegetative types on Tomales Point in 1980 and 1981.

Table 3. Number of grass and forb taxa categorized to growth form for each vegetative type and year.

Vegetative Type	Plant Type	Growth Form: Annual 1980	Annual 1981	Perennial 1980	Perennial 1981	Unknown 1980	Unknown 1981	Total 1980	Total 1981
Baccharis Grassland	forbs	9	28	21	41	5	5	35	74
	grasses	7	10	13	15	2	2	22	27
Lupine Grassland	forbs	11	38	22	32	7	12	40	82
	grasses	8	9	8	12	3	1	19	22
Open Grassland	forbs	3	29	18	31	2	3	23	63
	grasses	7	8	10	13	1	1	18	22
Thick Scrub	forbs	4	16	13	20	3	4	20	40
	grasses	4	6	2	6	1	2	7	14

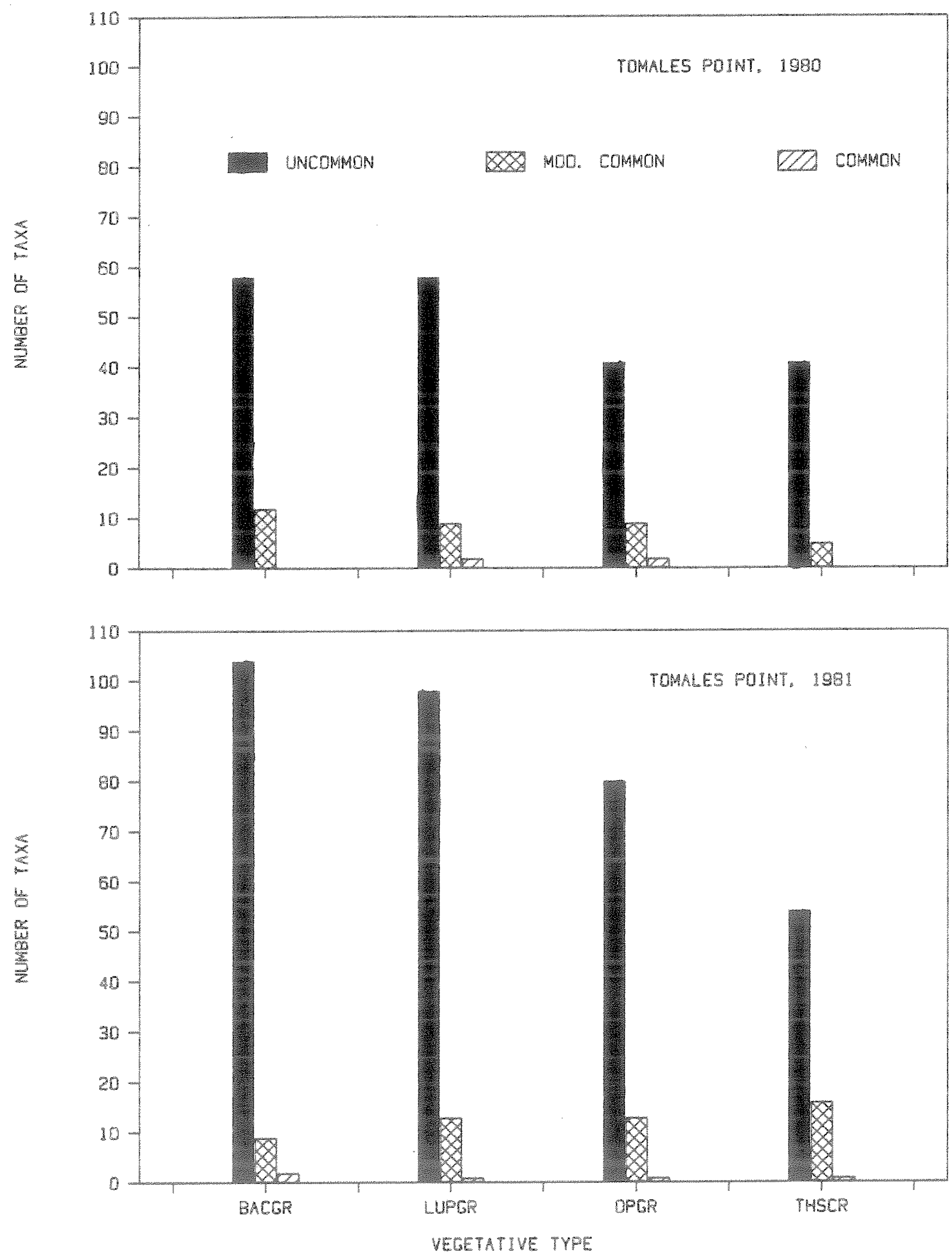

Figure 17. Number of plant taxa encountered in each vegetative type classified as: uncommon (< 1%); moderately common (> 1%, < 5%); and dominant (> 5%) for 1980 and 1981.

vegetative types with species in the "dominant" category.

Selection of species contributing five percent or more of the total canopy hits in any vegetative type, and hence classified as dominants, show ten species made up 47 to 65 percent of the plant cover in 1980 (Table 4) and 11 species made up 40 to 63 percent of the plant cover in 1981 (Table 5). The composition of species shifted between years: perennial ryegrass (Lolium perenne), bracken fern (Pteridium aquilinum) and willow (Salix Hindsiana) were dominant in at least one vegetative type in 1980 but not 1981. Cow-parsnip (Heracleum lanatum), meadow barley (Hordeum brachyantherum) and needlegrass (Stipa pulchra) contributed more than five percent of the relative cover in 1981 but not 1980. Comparisons between years reveals significantly greater mean occurrence of bracken fern, meadow barley and sheep sorrel (Rumex Acetosella) in 1981 than 1980 (Table 6).

Herbaceous Productivity and Utilization

The seasonal abundance of herbaceous plant standing crop within and outside exclosures shows the same pattern in all three grassland types (Fig. 18): there is a marked increase in biomass from February to June 1980 and a

Table 4. Mean occurrence (and standard error) of plant species classified as dominant in any vegetative type for 1980 (N = 11,083).

	Vegetative Type							
	Thick Scrub		Baccharis Grassland		Open Grassland		Lupine Grassland	
Taxon	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
LOWER PLANTS								
Pteridium aquilinum	9.9	2.3	3.8	2.4	3.9	2.1	3.3	1.1
FORBS								
Myrica californica	12.3	8.6	0.2	0.2	0.3	0.3	0.0	0.0
Plantago lanceolata	1.7	1.7	17.9	3.4	9.9	4.1	14.1	3.9
GRASSES								
Aira caryophyllea	4.3	3.0	26.7	3.8	11.4	4.5	21.9	4.8
Bromus mollis	3.0	2.1	27.7	7.5	42.7	9.8	35.5	4.6
Bromus rigidus	0.0	0.0	3.6	3.6	16.1	7.8	20.9	3.1
Festuca dertonensis	3.3	2.8	35.1	6.5	44.0	10.1	41.5	6.9
Lolium multiflorum	0.0	0.0	0.4	0.4	18.3	10.8	13.5	5.8
Lolium perenne	0.3	0.3	35.7	6.4	31.4	8.1	52.0	8.2
SHRUBS								
Baccharis pilularis	24.3	6.2	16.4	3.9	4.6	4.4	2.1	1.0
Rhus diversiloba	18.7	3.2	8.8	2.8	2.0	1.8	0.4	0.3
Rumex Acetosella	1.0	1.0	8.4	2.1	17.9	2.6	16.3	2.2
TREES								
Salix Hindsiana	14.7	14.6	0.0	0.0	0.0	0.0	0.0	0.0

Table 5. Mean occurrence (and standard error) of plant species classified as dominant in any vegetative type for 1981 (N = 17,916).

	Vegetative Type							
	Thick Scrub		Baccharis Grassland		Open Grassland		Lupine Grassland	
Taxon	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
FORBS								
Heracleum lanatum	36.0	12.8	9.8	5.4	7.3	4.9	1.2	0.7
Plantago lanceolata	9.3	8.4	37.5	9.9	22.4	12.8	21.6	5.6
GRASSES								
Aira caryophyllea	30.7	15.3	38.8	9.3	14.3	5.5	20.8	5.1
Bromus mollis	8.7	5.5	43.4	10.9	28.3	8.1	42.5	9.5
Bromus rigidus	0.7	0.7	6.8	2.0	26.9	11.9	36.6	7.5
Festuca dertonensis	20.0	10.8	38.4	12.1	44.3	7.8	46.5	6.6
Hordeum brachyantherum	0.3	0.3	12.0	4.0	36.6	8.3	27.2	5.8
Lolium perenne	0.3	0.3	32.2	8.5	24.1	10.1	35.2	7.4
Stipa pulchra	1.0	1.0	23.7	9.4	0.4	0.3	0.0	0.0
SHRUBS								
Baccharis pilularis	52.0	10.6	25.5	6.0	5.0	4.5	3.6	1.6
Rhus diversiloba	31.0	6.2	12.3	5.6	2.6	2.0	0.7	0.3
Rumex Acetosella	4.7	4.6	13.7	3.9	39.5	8.3	29.9	4.3

Table 6. Mean and standard error of occurrence of dominant plant species in 1980 (N = 11,083) and 1981 (N = 17,916). Means not significantly different from each other ($P \geq 0.05$) (Duncan's multiple range test), are connected by a common line.

Taxon	Year 1980 $\bar{x}$	Year 1980 SE	Year 1981 $\bar{x}$	Year 1981 SE
LOWER PLANTS				
Pteridium aquilinum	4.0	0.9	7.6	1.5
FORBS				
Heracleum lanatum	1.8	0.6	7.4	2.4
Myrica californica	1.1	0.8	1.1	1.1
Plantago lanceolata	13.1	2.3	24.7	4.5
GRASSES				
Aira caryophyllea	19.6	2.8	24.8	3.9
Bromus mollis	32.2	3.7	37.1	5.2
Bromus rigidus	15.6	3.1	24.3	4.7
Festuca dertonensis	41.8	4.7	41.8	4.7
Hordeum brachyantherum	0.2	0.2	23.0	3.7
Lolium multiflorum	10.1	3.5	9.8	3.6
Lolium perenne	30.8	4.9	29.3	4.7
Stipa pulchra	2.1	1.3	6.5	2.9
SHRUBS				
Baccharis pilularis	8.2	1.9	13.7	3.2
Rhus diversiloba	4.3	1.2	6.5	2.1
Rumex Acetosella	13.3	1.5	25.6	3.3
TREES				
Salix Hindsiana	1.2	1.2	2.0	2.0

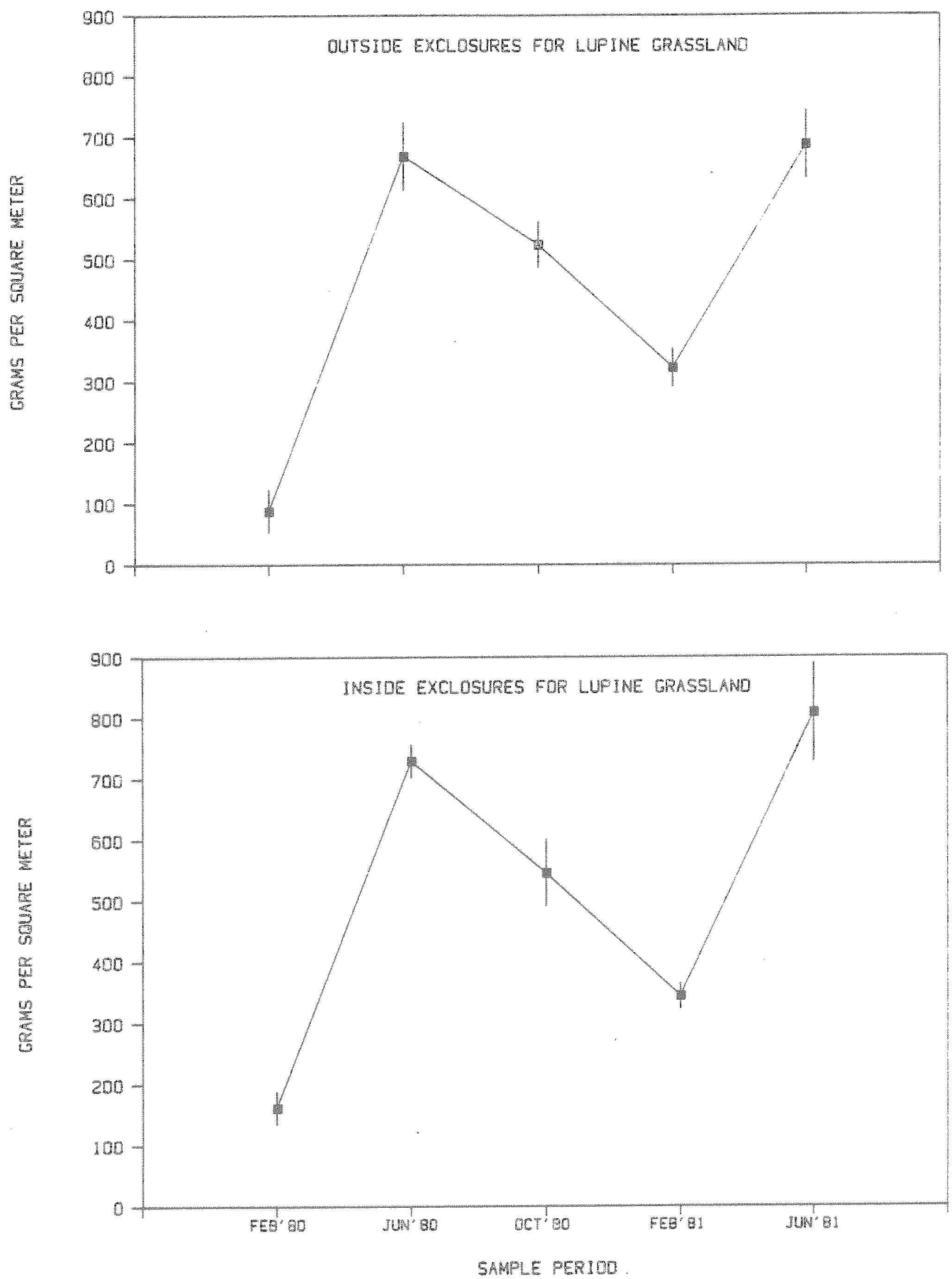

Figure 18. Mean and standard error (vertical bar) of herbaceous standing crop inside and outside exclosures for the three grassland types for each sample period.

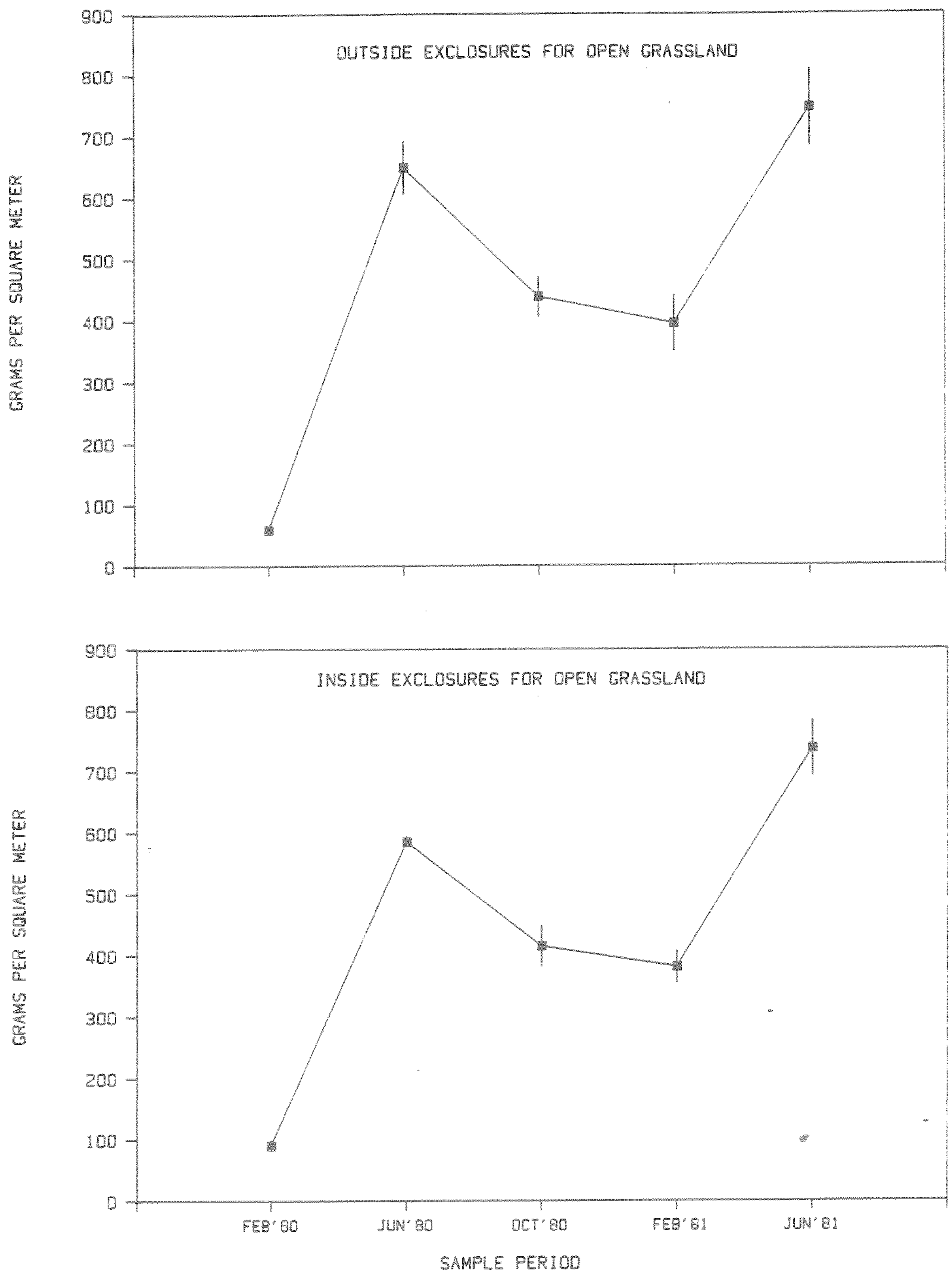

Figure 18. Continued.

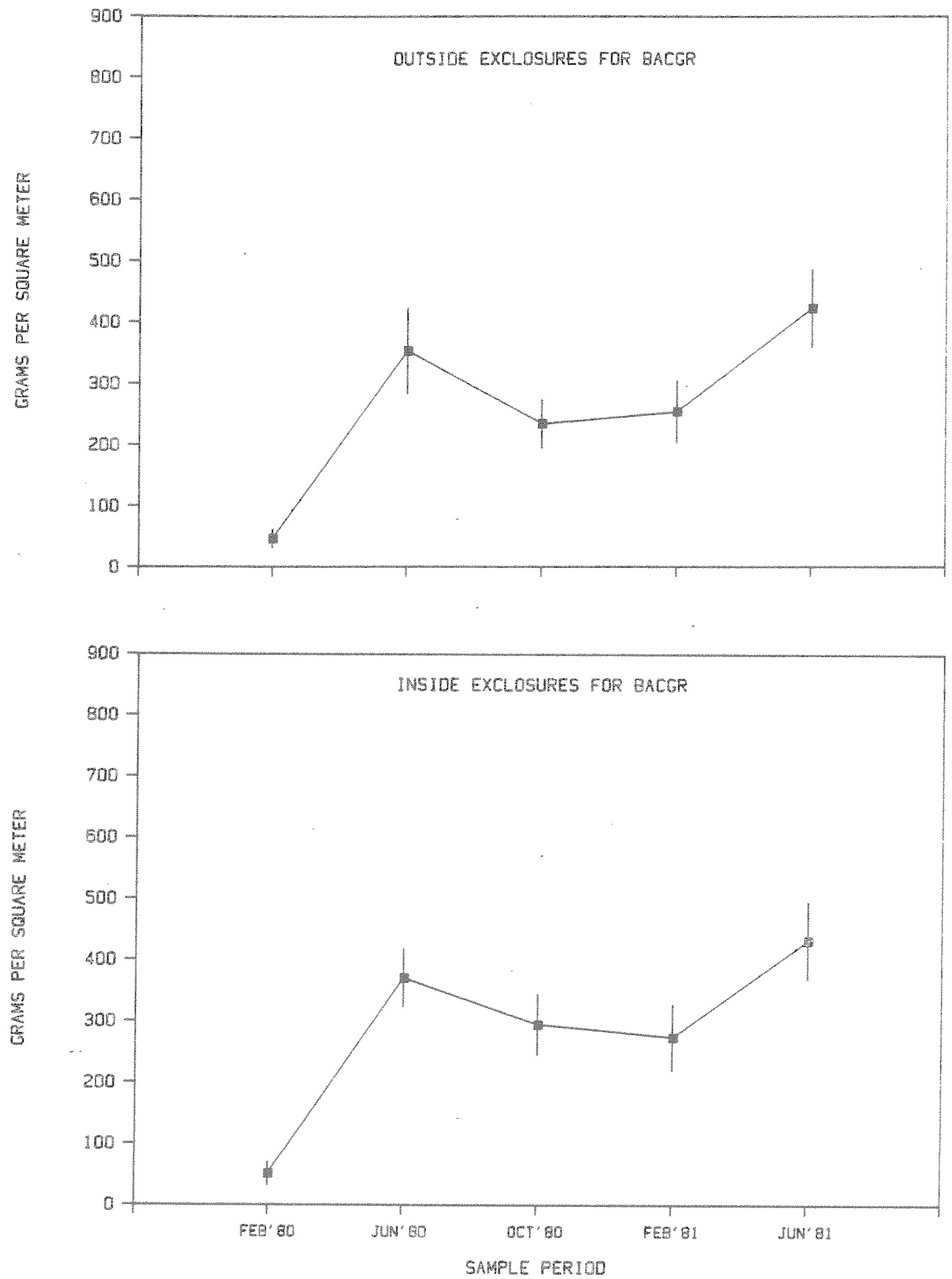

Figure 18. Continued.

moderate decline in October continuing through February 1981 followed by another upswing in June. Analysis of variance revealed highly significant differences between the grassland types in herbaceous standing crop inside exclosures in all sample periods except February 1981 (Table 7), and highly significant differences in herbaceous standing crop outside exclosures in three of the five sample periods (Table 8). Duncan's multiple range tests showed significant differences in mean herbaceous standing crop inside exclosures between at least two grassland types in all sample periods except February 1981 and between all grassland types in June and October 1980 (Table 9). Significant differences between grassland types in herbaceous standing crop outside exclosures were less common (Table 10).

Most annual herbaceous plant growth occurred between February and June of each year (Table 11). Analysis of variance showed highly significant differences between grassland types in herbaceous production for the June 1980 sample period only (Table 12). In that one instance, production in the lupine grassland type was higher than in the other two grassland types (Table 11). Production in June 1981 was lower than in June 1980 for all grassland types.

Table 7. Summary of analysis of variance for differences between vegetative types in herbaceous standing crop within exclosures for each sample period.

Sample period	N	F value	Prb >F
February 1980	27	9.42	0.0010**
June 1980	54	12.56	0.0001**
October 1980	53	8.42	0.0007**
February 1981	34	1.98	0.1549
June 1981	34	7.88	0.0010**

**Highly significant

Table 8. Summary of analysis of variance for differences between vegetative types in herbaceous standing crop outside exclosures for each sample period.

Sample period	N	F value	Prb >F
February 1980	27	1.32	0.2850
June 1980	54	8.18	0.0080**
October 1980	53	13.36	0.0001**
February 1981	34	2.53	0.0950
June 1981	34	6.44	0.0030**

**Highly significant.

Table 9. Mean herbaceous standing crop (g/m^2) inside exclosures in each of three grassland types. Differences (Duncan's multiple range test) in means connected by a common line are non-significant ($P \geq 0.05$).

Sample period	Grassland Type		
	Lupine Grassland	Open Grassland	Baccharis Grassland
February 1980	162	91	52
June 1980	730	586	371
October 1980	546	415	295
February 1981	381	344	275
June 1981	808	738	433

Table 10. Mean herbaceous standing crop (g/m^2) outside exclosures in each of three grassland types. Differences (Duncab's multiple range test) in means connected by a common line are non-significant ($P \geq 0.05$).

Sample period	Grassland Type		
	Lupine Grassland	Open Grassland	Baccharis Grassland
February 1980	89	59	46
June 1980	669	649	353
October 1980	524	439	234
February 1981	395	323	254
June 1981	688	747	423

Table 11. Mean herbaceous production (g/m^2) for each sample period in each of three grassland types. Differences (Duncan's multiple range test) in means connected by a common line are non-significant ($P \geq 0.05$).

Sample period	Lupine Grassland		Open Grassland		Baccharis Grassland	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
February 1980	-89.9	93.3	-114.1	39.1	-111.9	28.5
June 1980	643.5	55.1	480.2	53.6	326.4	42.7
October 1980	-125.1	58.2	-234.4	36.5	-58.1	58.6
February 1981	-107.6	77.7	7.5	45.6	65.9	39.4
June 1981	411.5	110.6	346.3	85.3	161.7	61.3

Table 12. Summary of analysis of variance for differences between grassland types in production of herbaceous plant material for each sample period.

Sample period	N	F value	Prb > F
February 1980	27	0.05	0.949
June 1980	54	7.55	0.001**
October 1980	53	2.86	0.067
February 1981	34	1.85	0.173
June 1981	30	1.36	0.274

**Highly significant.

Estimates of herbaceous plant material utilization have large standard errors associated with them (Table 13), and analysis of variance tests failed to detect differences in utilization between any grassland type (Table 14). Five estimates of negative utilization are the result of higher standing crop outside exclosures. Mean estimates of herbaceous productivity obtained from exclosures not clipped from October 1980 through June 1981 and from the sum of seasonal estimates of productivity are remarkably similar; Duncan's multiple range tests reveal no significant differences in productivity between grassland types for either estimator (Table 15).

Shrub Productivity and Utilization

Coyote bush was found in all vegetative types, whereas bush lupine was recorded in only the open grassland and lupine grassland types with the exception of a single plant in 1980 (Table 16). Analyses of variance showed differences in the average elliptical crown volume of coyote bush between vegetative types in 1980 and 1981 (Table 17). Duncan's multiple range tests revealed mean size of coyote bush in thick scrub differed from all other vegetative types in 1980 and from all but the baccharis grassland type in 1981, while there was no difference

Table 13. Mean herbaceous utilization (g/m^2) for each sample period in each of three grassland types. Differences (Duncan's multiple range test) in means connected by a common line are non-significant ($P \geq 0.05$).

Sample period	Lupine Grassland		Open Grassland		Baccharis Grassland	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
February 1980	73.6	32.1	66.6	39.3	5.5	12.5
June 1980	86.3	64.7	16.3	60.0	17.8	54.3
October 1980	17.9	32.8	-24.0	28.2	60.7	39.7
February 1981	-16.7	36.9	-10.9	41.0	17.9	49.5
June 1981	133.4	102.0	-97.9	62.4	-30.2	97.0

Table 14. Summary of analysis of variance for differences between grassland types in utilization of herbaceous plant material for each sample period.

Sample period	N	F value	Prb > F
February 1980	27	0.62	0.5438
June 1980	54	0.43	0.6522
October 1980	53	1.48	0.2375
February 1981	34	0.17	0.8486
June 1981	30	1.98	0.1580

Table 15. Annual productivity (g/m²) of herbaceous vegetation calculated as cumulative productivity from seasonal samples and measured as total productivity from exclosures not clipped from October 1980 to June 1981. Differences (Duncan's multiple range test) in means connected by a common line are non-significant ($P \geq 0.05$).

Sample type	Grassland Type								
	Lupine Grassland			Open Grassland			Baccharis Grassland		
	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Cumulative productivity	12	275.2	97.1	10	287.6	76.3	8	207.2	58.9
Total productivity	6	218.0	97.0	8	369.3	57.2	4	220.6	89.7

Table 16. Mean crown volume (m^3) of coyote bush and bush lupine in each of four vegetative types on Tomales Point. Differences (Duncan's multiple range test) in means connected by a common line are non-significant ($P \geq 0.05$).

Year	Species	Vegetative Type							
		Thick Scrub		Baccharis Grassland		Open Grassland		Lupine Grassland	
		$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
1980	*Baccharis pilularis*	0.21	0.06	0.09	0.01	0.12	0.02	0.04	0.01
	Lupinus arboreus	0.13	-	-	-	0.05	0.02	0.09	0.05
1981	*Baccharis pilularis*	0.15	0.04	0.07	0.01	0.05	0.01	0.04	0.01
	Lupinus arboreus	-	-	-	-	0.03	0.01	0.08	0.01

Table 17. Summary of analysis of variance for difference in crown volume of bush lupine and coyote bush between vegetative types for 1980 and 1981.

Year	Species	N	F value	Prb > F
1980	_B. pilularis_	305	5.15	0.002**
	L. arboreus	288	1.16	0.32
1981	_B. pilularis_	399	3.16	0.02*
	L. arboreus	148	2.85	0.09

*Significant. **Highly significant.

between the three other vegetative types in either year (Table 16). Analyses of variance showed no significant differences in the size of bush lupine in any vegetative type in either year (Table 17). The number of coyote bushes encountered increased from 1980 to 1981 and the number of bush lupine shrubs declined (Table 17).

Coyote bush within enclosures in lupine grassland was approximately three times more productive than in the thick scrub or Baccharis grassland types in 1980 and approximately twice as high in 1981 (Table 18). Inside exclosures, significant differences occurred in production per bush in both years (Table 19). Although the magnitude of the differences between lupine grassland and other vegetative types in productivity per coyote bush outside exclosures in 1980 (Table 20) was similar to that within exclosures, standard errors were much larger.

The estimate of coyote bush production outside exclosures in 1981 is not consistent with the value obtained in 1980 or for estimates from inside exclosures in both years. There were no significant differences in coyote bush production outside exclosures between any vegetative types (Table 19).

Table 18. Mean annual productivity (gms/$\bar{x}$ shrub) inside exclosures for coyote bush in three vegetative types and for bush lupine in the lupine grassland type. Means connected by a common line do not differ significantly ($P \geq 0.05$) (Duncan's multiple range test).

Year	Species	N	Vegetative Type: Thick scrub $\bar{x}$	Thick scrub SE	Baccharis Grassland $\bar{x}$	Baccharis Grassland SE	Lupine Grassland $\bar{x}$	Lupine Grassland SE
1980	*Baccharis pilularis*	8	225	24.8	261	28.6	836	110.9
	Lupinus arboreus	8	-	-	-	-	321	93.0
1981	*Baccharis pilularis*	8	207	27.6	215	21.5	531	-
	Lupinus arboreus	8	-	-	-	-	176	70.7

Table 19. Summary of analysis of variance for differences between vegetative types in annual production per coyote bush for both inside and outside exclosures.

Sample period	Site	N	F value	Prb > F
June 1980	Inside exclosure	10	43.59	0.0001**
	Outside exclosure	10	2.56	0.1460
June 1981	Inside exclosure	11	19.58	0.0020**
	Outside exclosure	11	1.40	0.3070

**Highly significant.

Table 20. Mean annual productivity (gms/$\bar{x}$ shrub) outside exclosures for coyote bush in three vegetative types and for bush lupine in the lupine grassland type. Means connected by a common line do not differ significantly ($P \geq 0.05$) (Duncan's multiple range test).

Year	Species	N	Thick Scrub $\bar{x}$	Thick Scrub SE	Baccharis Grassland $\bar{x}$	Baccharis Grassland SE	Lupine Grassland $\bar{x}$	Lupine Grassland SE
1980	*Baccharis pilularis*	8	237	15.1	289	45.9	834	574.0
	Lupinus arboreus	8	-	-	-	-	238	70.6
1981	*Baccharis pilularis*	8	213	34.0	245	23.8	126.1	126.1
	Lupinus arboreus	8	-	-	-	-	337	168

Estimates of utilization suggest negative use of coyote bush in all vegetation types in both years with the exception of lupine grassland in 1981 (Table 21). The utilization estimate for bush lupine in 1981 was negative. However, the estimates of production leading to this estimate are questionable for the reasons discussed above. Negative growth suggests sampling methods may have modified production or permitted greater consumption of browse within exclosures. Exclusion of large herbivores from around shrubs may have permitted an increase in herbaceous standing crop which either directly interfered with shrub production, or provided cover for smaller herbivores, including invertebrates, that consumed a greater proportion of the shrub production inside than outside exclosures. The high mortality of mature bush lupine throughout the study area (Lathrop and Gogan 1985) may have confounded estimates of production and utilization of this species. Many of the twigs tagged in June 1980 were dead in June 1981. However, all estimates of production and utilization in this study are highly variable, and the estimates of negative utilization may simply be the result of a low sampling intensity.

Table 21. Mean utilization (gms/$\bar{x}$ shrub) of coyote bush in each of three vegetative types and of bush lupine in lupine grassland in 1980 and 1981.

Year	Species	N	Vegetative Type: Thick Scrub		Baccharis Grassland		Lupine Grassland	
			$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
1980	*Baccharis pilularis*	8	-12.5	39.1	-28	24.5	2.0	463.1
	Lupinus arboreus	8	-	-	-	-	82.3	40.8
1981	*Baccharis pilularis*	8	-5.0	59.2	-29	40.8	405	-
	Lupinus arboreus	8	-	-	-	-	-169	123.0

DISCUSSION

Environmental factors and past land use practices likely affected the distribution of vegetative types on Tomales Point. The prevalence of lupine grassland just inland from ocean bluffs has been noted previously (Hektner and Foin 1977a, Heady et al. 1977, Lathrop and Gogan 1985). Laboratory experiments have shown the viability of bush lupine seedlings is depressed by the levels of salinity occurring along the bluffs (Barbour et al. 1973). Investigations on Tomales Point have shown the importance of soil type in the distribution of bush lupine (Crawford et al. 1983). Abrupt boundaries between the open grassland type and other vegetative types suggest the open grassland may represent formerly cultivated fields. The thick scrub type generally occurs in east-facing gullies along the eastern side of Tomales Point, well protected from the prevailing northwesterly winds.

The 293 species (201 native, 92 exotic) identified on Tomales Point (Lathrop and Gogan 1985) exceeds by 50 the number recorded at Bodega Head, Sonoma Co. (Barbour 1970, 1972), although the proportion of native to exotic species is similar. Dominant plant species on Tomales Point have been recognized as characteristic of the coastal

prairie-coastal scrub mosaic in Mendocino and Sonoma Counties. (Heady et al. 1977). Determining species composition in June is likely to result in identification of a high proportion of the species present since the total number of species flowering is greatest in June (Barbour et al. 1973).

Shifts in botanical composition and species diversity recorded between 1980 and 1981 may be predicted following cessation of livestock grazing. However, the pattern of precipitation and temperature affect grassland species composition (Heady 1958, Pitt and Heady 1978) as does timing of sampling (Pitt and Heady 1978). Studies in the California annual grassland type show annual changes in botanical composition are primarily a response to shifting weather patterns with factors such as grazing intensity modifying the magnitude rather than the direction of shifts in botanical composition resulting from changing weather patterns (Pitt 1975). The history of such factors (e.g., fire regime, grazing pressure, cultivation) are more likely reflected in cover of perennial plant species. The increase of purple needlegrass (S. pulchra) on Tomales Point from 1980 to 1981 is consistent with an initial increase in this species' abundance on other California ranges released from the grazing pressure of domestic

livestock (Bartolome and Gemmil 1981).

Similarly, differences in weather patterns and in timing of sampling make comparisons of botanical composition of the coastal prairie-coastal scrub mosaic difficult to interpret. Comparison of plant species identified as dominant in the grassland types of Tomales Point in 1980 and 1981 and in the Seashore's pastoral zone in "summer" 1978 (Elliott 1982) is undoubtedly affected by weather patterns. Sampling on Tomales Point in this study was done in years of "good" rainfall, while the pastoral zone was sampled following a drought (Chapter II). Species identified as dominant (more than 5 percent cover) in the grassland types of Tomales Point and in the pastoral zone include perennial ryegrass (L. perenne), fescue (F. dertonensis), and English plantain (P. lanceolata) (Elliott 1982). All other species dominant on Tomales Point constituted less than five percent of the cover in the pastoral zone. Only foxtail (H. leporinum) was recorded as dominant in the pastoral zone but not on Tomales Point. Comparison of sites within the pastoral zone sampled during July 1972 (Elliott and Wehausen 1974) a year with a more typical rainfall pattern (Chapter II), and sites sampled by this study shows five of ten species dominant in any of three plots in the pastoral zone were also dominant on

Tomales Point in either 1980 or 1981. Two perennial grass species recorded as dominant in the pastoral zone, tufted hairgrass (Deschampsia caespitosa holciformis) and California oatgrass (Danthonia californica) were not dominants on Tomales Point although both species occur there (Appendix I, Lathrop and Gogan 1985). Soft chess (B. mollis) and purple needlegrass (S. pulchra) were dominant in the grassland areas of Tomales Point, but not in the pastoral zone plots (Elliott and Wehausen 1974).

Only one species, silver hairgrass (A. caryophyllea), is dominant at both Bodega Head, Sonoma Co., (Barbour 1970) and Tomales Point. Four other species dominant in the grassland areas of Bodega Head (Barbour 1970) were present but not dominant in the plant cover of Tomales Point.

Comparison of the species composition of Tomales Point to the coastal prairie-coastal scrub of Sea Ranch, Sonoma Co., (Hektner and Foin 1977b) highlights the confounding factor of seasonal differences. Sampling at Sea Ranch in August and September showed no more than three species making up more than 60 percent of the relative cover in five vegetative types (Hektner and Foin 1977b) whereas 10 or 11 species made up between 40 and 65 percent of the relative cover in the four vegetative types on Tomales

Point. Only one species, English plantain, is dominant at both locales. Coyote bush was not present on the plots sampled at Sea Ranch (Hektner and Foin 1977b).

The identification of vegetative types in this study is in accord with earlier classifications of the coastal prairie-coastal scrub mosaic (Barbour 1970, Hektner and Foin 1977a, Heady et al. 1977). However, the four vegetative types are variable and integrade with each other. Seventeen plant communities were identified in detailed vegetative mapping of Tomales Point (Lathrop and Gogan 1985). The Calamagrostis nutkaensis type of Hektner and Foin (1976a) is included in the baccharis grassland type of this study. The thick-scrub of this study represents particularly dense stands of baccharis scrub and northern coastal scrub as classified by Grams et al. (1977) or baccharis brushland (McBride 1974). The lupine grassland is comparable to the lupine scrub of Heady et al. (1977).

Successional relationships between the four vegetative types are unclear. Open grasslands may be seral to baccharis grassland and lupine grassland. A comparison of aerial photographs of Bodega Head between 1954 and 1970 revealed a three-fold increase in the bush lupine areas

(Barbour 1972). Examination of aerial photographs of Tomales Point between 1952 and 1974 and vegetation mapping in 1981 reveal shifts in the distribution of lupine grassland, with some open grassland areas being invaded by bush lupine. Elsewhere lupine disappeared and in other stands lupine density has remained stable (Lathrop and Gogan 1985). In the absence of livestock grazing, grass cover may become too dense to permit establishment of bush lupine (Davidson and Barbour 1977). Such conditions may produce bush lupine stands with stable boundaries (Davidson and Barbour 1977).

Succession between open grassland and baccharis grassland is not clear. Coyote bush did not invade open grasslands on Tomales Point between 1952 and 1981 (Lathrop and Gogan 1985). However, the process has become evident on some sites between 1981 and 1985 (Fig. 15). Coyote bush invasion into grassland following release from grazing by domestic stock has been documented in the Berkeley Hills, Alameda Co. (McBride and Heady 1968, McBride 1974). Controlled experiments show establishment of coyote bush seedlings may be favored by "wet" years and a high incidence of summer fog (daSilva and Bartolome 1984). Precipitation levels between 1980 and 1983 were especially high (Chapter II) and Tomales Point is often bathed in

summer fog.

No evidence to date indicates that baccharis grassland is seral to the thick scrub type. Although both types are characterized by coyote bush, individual bushes are far more robust in the thick scrub type. The importance of site characteristics in the establishment of the thick scrub is studied. However, no stands of thick scrub currently occur away from steep ravines protected from the prevailing winds. Thick scrub on the Point Reyes Peninsula may be seral to woodland or forest (Grams et al. 1979); comparable areas of thick scrub in the Berkeley Hills show such a pattern (McBride 1974).

The general pattern of herbaceous standing crop, varying from greatest biomass in June to lowest in February has been reported repeatedly for northern California annual grasslands (Ratliff and Heady 1962, Pitt and Heady 1978, Bartolome et al. 1980). High annual variation in peak herbaceous standing crop is greatly influenced by the previous fall and winter weather patterns (Pitt and Heady 1978) and mulch levels (Bartolome et al. 1980). Herbaceous standing crop measured in June in lupine grassland and open grassland (Table 10) exceeds the range of values for 18 years at Hopland, Mendocino Co. (Pitt and Heady 1978), but

herbaceous standing crop measured in June in baccharis grassland falls within that range. Similarly, peak herbaceous standing crop measured at 645 g/m^2 for ungrazed grasslands in the Berkeley Hills (Ratliff and Heady 1962) approximates values on Tomales Point for lupine grassland and open grasslands but exceed estimates for baccharis grassland. Generally, peak herbaceous standing crop in the lupine grassland and open grassland sites exceeded peak herbaceous standing crop at six sites throughout California (Bartolome et al. 1980) while peak herbaceous standing crop in the baccharis grassland did not. Herbaceous standing crop in lupine grassland on Tomales Point in October 1980 is greater than at four sites on the Point Reyes Peninsula south of Tomales Point measured in the same month (Elliott 1982:113). Herbaceous standing crop in open grassland and baccharis grassland approximates and is below these four other sites, respectively.

Annual herbaceous production in the three grassland types on Tomales Point in the 1980-1981 growing season compare favorably with estimates of productivity at three of four sites on the Point Reyes Peninsula south of Tomales Point for the 1978-1979 and 1979-1980 growing seasons although one of the three sites was heavily fertilized

(Elliott 1982:111). Annual herbaceous productivity on the three grassland types of Tomales Point was approximately ten times higher than on a grassland type considered representative of pristine coastal prairie by Elliott (1982:111).

Differences in the volume of coyote bush between vegetation types possibly reflect age and degree of shelter from the prevailing northwesterly winds. Bushes achieve their greatest size in the more protected east-facing canyons. Differences in size may also reflect differences in the distribution of two subspecies of coyote bush: the more robust, erect B. pilularis consanguinea is most common in the thick scrub and baccharis grassland types while the smaller, prostrate B. pilularis pilularis is most common in the exposed lupine grassland type. The small size of coyote bush may be due to either the prevalent subspecies or represent young individual bushes resulting from recent invasion of the open grassland type by coyote bush.

The increase in number of individual bushes of this species encountered corresponding with an increase in the cover of coyote bush from 1980 to 1981. Possible encroachment of grasslands by coyote bush has been discussed above. The decline in the number of individual

bush lupine encountered from 1980 to 1981 reflects the demise of entire stands of this species (Lathrop and Gogan 1985).

The similarity in estimates of shrub production for 1980 and 1981 (Table 20) suggest considerable annual shrub growth in winter and spring. Samples were tagged in February and clipped in June 1980, and were retagged immediately but not clipped until June 1981. Hence, the 1980 sample only measured growth between February and June 1980 while the 1981 sample measured growth between June 1980 and June 1981. No estimates of production or utilization of coyote bush or bush lupine were found in the literature.

CONCLUSIONS

The four vegetative types identified on Tomales Point at the onset of this study differ in their distribution over the area and in the species making up more than five percent cover. Use of permanent photographic stations is a practical means of monitoring vegetative changes. Only 12 (1981) or 13 (1980) of the 293 plant species identified on Tomales Point are dominants (make up more than five percent of the cover) in any of the four vegetative types. These

dominant species are characteristic of the coastal prairie-coastal scrub mosaic. Recorded differences in botanical composition between years are likely attributable to differences in weather patterns although elimination of cattle grazing will undoubtedly have a long-term effect.

The period of greatest herbage production occurs in the spring (between February and June), with peak standing crop in June. Standing crop declines from June through the following February. Estimates of peak herbaceous standing crop in open grassland and lupine grassland on Tomales Point exceed measurements for other sites in California but peak herbaceous standing crop in the baccharis grassland does not.

To date, the seral relationships among the four vegetative types are unclear. However, areas of open grassland representing old fields may be seral to baccharis grassland. Invasion of open grassland by baccharis is already underway.

CHAPTER IV

COMPARATIVE DYNAMICS OF TWO REINTRODUCED TULE ELK POPULATIONS

An introduced ungulate population can provide useful information on population processes because the "potential and limits of its reaction to the environment" are evident at the point of greatest displacement from equilibrium with environmental forces (Caughley 1976:196). However, few studies of ungulate populations immediately following introduction have been reported. The paucity of such information has led to experimental manipulation of populations to duplicate growth from low numbers (McCullough 1979, 1982). I report here on growth rates for two reintroduced populations of tule elk: Point Reyes and Grizzly Island. Both areas supported tule elk, at least seasonally, in pristine times (McCullough 1969). The numbers of elk introduced were similar, with both populations numbering 17 in 1978 ~~1979.~~

METHODS

Individual elk at Point Reyes usually were located twice each week between July 1979 and September 1981, and

monthly from October 1981 through August 1984. The herd composition was recorded by sex and age class as calf, yearling or adult. Ear-tags permitted identification to age class. In 1980 and 1982 sex of calves was determined at approximately 6 months of age. In 1981, four of five live-born calves were captured within the first week of life and their sex determined.

Information on numbers and composition of elk at Grizzly Island was obtained from refuge records and my tallies of the herd composition each July from 1979 through 1984 as at Point Reyes, except that yearling and adult females were not distinguished. However, the number in each age class could be determined from numbers of female calves the previous year and female mortality. Lack of dispersal and complete absence of mortality between three and 15 months of life permitted calculation of secondary sex ratio for each cohort at three months of age through 1982. Calving rates are expressed as calves per 100 females two years of age and over. Only numbers of calves and total numbers were recorded in 1984. All tallies are repeated total counts with no animals missed.

Rates of population growth ($\hat{r}_m$) for the Point Reyes and Grizzly Island elk were calculated with Caughley's

(1977:109) formula and compared to similar calculations for introduced elk populations described in the literature. The observed r_m is taken as an approximation of r_m, the intrinsic rate of increase (Caughley and Birch 1971, Caughley 1977). "The rate r_m is the appropriate statistic ... for comparing the favourability of two environments occupied by one species." (Caughley 1977:55). All estimates of rate of population increase ($\hat{r}_m$) were obtained from regression of $\log_e$ numbers on time with the slope of the regression line equal to $\hat{r}_m$ (Caughley and Birch 1971, Caughley 1977).

RESULTS

History of Reintroductions

Point Reyes--Ten adult elk (2 males, 8 females) were transported in March 1978, from San Luis National Wildlife Refuge, Merced Co., to a holding pen on the 1030 ha fenced portion of Tomales Point. Nine calves (1978 cohort) were born while the animals were confined within the pen (Ray 1981). Ten adults and seven surviving calves (4 males, 3 females) were released to the entire range in September 1978 (Table 22). Three adult males from the Owens Valley, Inyo Co., were reintroduced in December 1981. They were

Table 22. Numbers of tule elk by age and sex at Point Reyes National Seashore, California, on August 1 of each year, 1978-84.

Year	Calves			Yearlings		2-Yr.-Olds		Adults		Total
	Unsexed	M	F	M	F	M	F	M	F	
1978	2[a]	4	3[b]	0	0	0	0	2[b]	8[b]	17
1979		1	2	4[b]	2	0	0	0	6	15
1980		1	0	1	2[b]	3[b]	2[b]	0	6	15
1981		2	4[b, c]		1	0	1	1	2	7 17
1982		4	4	2	2	1	0	3	8	24
1983	8	-	-	4	4	2	2	4	8	32
1984	9	-	-	-	-	-	-	-	-	41
1985	15	-	-	-	-	-	-	-	-	55

[a] Unsexed calves found dead. '86 70

[b] Mortality occurred in following year.

[c] Includes stillborn premature calf.

sighted occasionally in January and February 1982, but subsequently disappeared and are not considered further.

Grizzly Island--Seven adult elk (4 males, 3 females) were relocated to Grizzly Island from the Tule Elk State Reserve [Tupman], Kern Co., in February 1977. The animals were restricted to a holding pen until released on-site in May. A yearling female, originally from Owens Valley, was released at Grizzly Island later that year. In May 1978, an adult female from Owens Valley joined the herd (Table 23). One of the original four adult males was moved to another release site. An adult male was poached in November 1979, and a male seriously injured in the rut was sacrificed in September 1982.

Population Growth Rate

The $\hat{r}_m$ for the Grizzly Island reintroduction was approximately twice that of the overall $\hat{r}_m$ for the Point Reyes herd (Fig. 19). The slopes of the regression lines are significantly different ($t = 1.9$ $df = 11$; $P \leq 0.05$). However, $\hat{r}_m$ for the Point Reyes herd for 1981-1984, with an initial size of 17 but greatly improved calving rates, closely approximates $\hat{r}_m$ for the Grizzly Island herd, and the slopes of the regression lines do not differ

Table 23. Numbers of tule elk by age and sex at Grizzly Island State Wildlife Management Area, California, on August 1 of each year, 1977-84.

Year	Unsexed	Calves M	Calves F	Yearlings M	Yearlings F	2-Yr.-Olds M	2-Yr.-Olds F	Adults M	Adults F	Total
1977		0	3	0	1	0	0	4	3	11
1978		2	3	0	3	0	1	4[a]	4	17
1979		3	5	2	3	0	3	3[a]	5	24
1980		6	5	3	5	2	3	2	8	34
1981	3[b]	5	8	6	5	3	5	4	11	47
1982		4	10	5	8	6	5	7[a]	16[a]	61
1983	17[a]	-	-	4	10	5[a]	8	11	20	75
1984	24	-	-	-	-	-	-	-	-	96

[a] Mortality occurred in following year.

[b] 3 unsexed calves found dead.

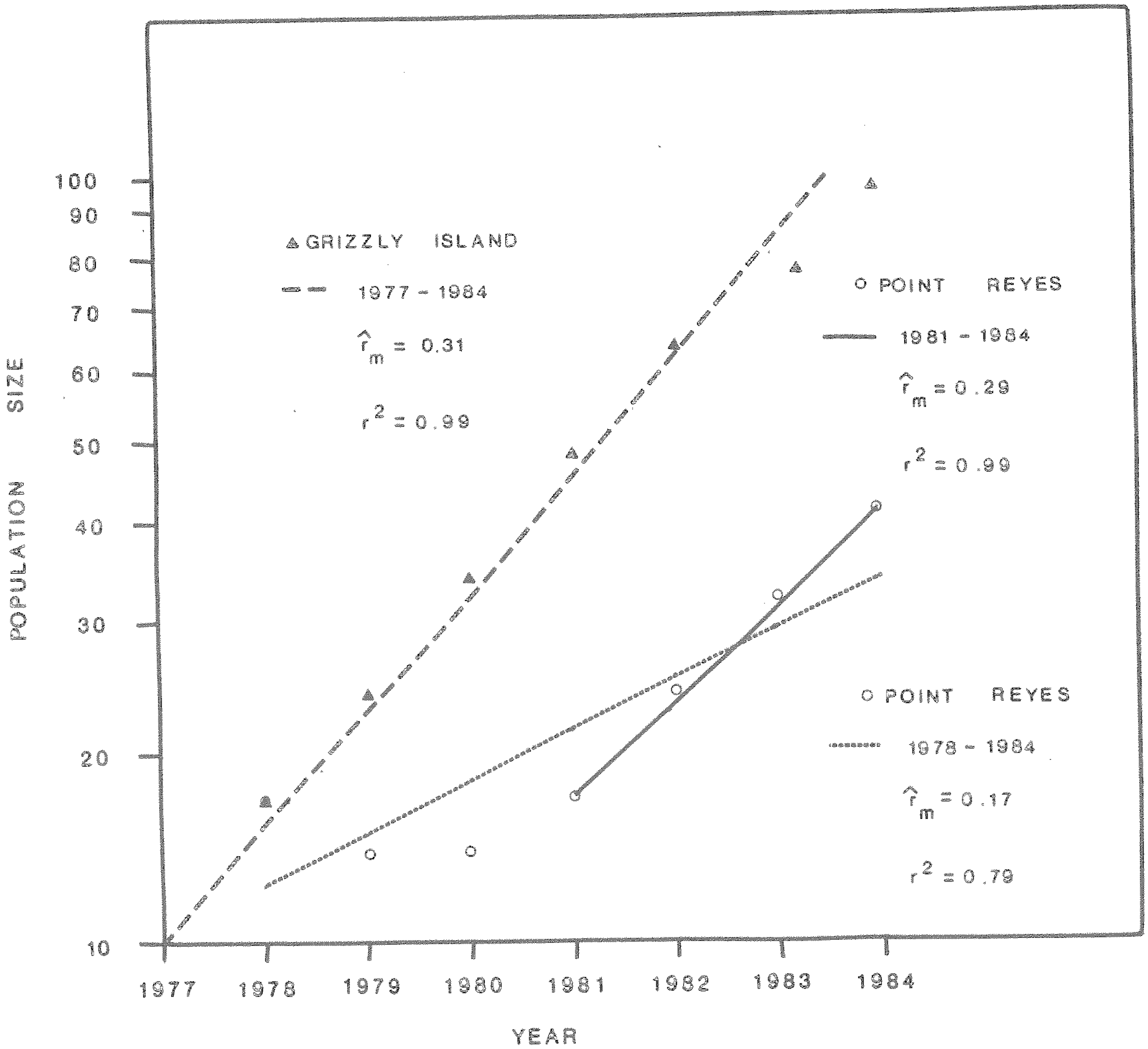

Figure 19. Growth rates of tule elk reintroduced to Point Reyes and Grizzly Island.

significantly ($t = 1.68$; $df = 8$; $P \geq 0.05$). Estimates of $\hat{r}_m$ of other recently reintroduced and unhunted populations of elk are presented for comparison (Table 24). With the exception of Yosemite Valley, growth rates for these populations are calculated from censuses or back-calculation of population size. Both methods likely underestimated population size, and hence calculated rates of growth may be low. Comparison of growth rates for populations 6-8 years from the time of introduction (7 years is the limit of observation on Point Reyes and 8 years the limit of information on Grizzly Island) (Table 24) shows the rate of growth of the Point Reyes population was the lowest in the comparison. The $\hat{r}_m$ for the Grizzly Island population was exceeded only by the rate of growth of elk introduced to Afognak Island, Alaska.

Mortality

Numbers declined at Point Reyes as three adults (1 male, 2 females) died of natural causes between May and August 1979. The other adult male was so sick he was removed from the range in July 1979 and is considered a mortality. This pulse of adult mortality is attributed to copper deficiency and general malnutrition once the elk were free-ranging (Chapter V). There has been no

Table 24. Size of original introduction, numbers of elk in following years, and calculated $\hat{r}_m$ for select locations.

Location	Number of Years Following Introduction	Number of Elk	Calculated $\hat{r}_m$	Reference
Afognak Island,	1	8		Burris and McNight 1973
Alaska	2	13		Burris and McNight 1973
	6	50-60	0.37	Burris and McNight 1973
	9	100		Burris and McNight 1973
	13	147		Troyer 1960
	20	212	0.17	Batchelor 1965
Wichita Mts.,	1	21		Halloran 1962
Oklahoma	2	24		Halloran 1962
	11	125		Halloran 1962
	14	300	0.22	Halloran 1962
Yosemite Valley,	1	6		Moffitt 1934
California	2	8		Moffitt 1934
	3	11		Moffitt 1934
	4	13		Moffitt 1934
	5	15		Moffitt 1934
	6	16	0.18	Moffitt 1934
	7	19		Moffitt 1934
	8	22		Moffitt 1934
	9	23		Moffitt 1934
	10	23		Moffitt 1934
	11	22	0.13	Moffitt 1934
Tyson Park,	1	10		Murphy 1963
Missouri	8	103	0.29	Murphy 1963

additional mortality among the original animals. Natural mortality in elk 3 months and older at Grizzly Island has been limited to an adult male in November 1982, a female from the original introduction in July 1983, and a 2-year-old male in September 1983.

There are markedly different patterns of mortality from 3 months through 2 years of life for tule elk born at each site through August 1983 (Tables 22 and 23). There has been no mortality in animals born to the Grizzly Island population through the end of the second year of life. In contrast, there have been a number of losses at Point Reyes. A 1978-cohort female at Point Reyes died of undetermined natural causes in August 1979. A 1978-cohort male succumbed to paratuberculosis in November 1980, and a female of the same cohort was destroyed the following March after having been diagnosed positive for the disease (Jessup et al. 1981). One of two females of the 1979 cohort was diagnosed positive for paratuberculosis and destroyed in July 1981. Her calf at heel (1981 cohort) was not taken, but was observed exhibiting symptoms of the disease in April 1982. It was never relocated. Four of nine of the females entering the yearling and 2-year-old age classes died before the end of the year, with all but one of these losses attributable to paratuberculosis. Only

two of 13 males in the same age classes died, and only one was lost to paratuberculosis. Thus, paratuberculosis disproportionately affected the female segment of the population. A similar ratio has been reported in cattle (Bruner and Gillespie 1973), but there was no significant difference between sexes in the incidence of paratuberculosis in two exotic deer species on the Point Reyes Peninsula (Riemann et al. 1979).

Reproductive Success

Criteria used in assessing reproductive success include age of sexual maturity, pregnancy rate, twinning rate, stillborn-perinatal loss, sex ratio of calves, and birth weight. Studies of wild ungulate populations show that the nutritional plane of females -- commonly inferred from density estimates -- affects reproductive success, particularly in younger females (Skoog 1968, Verme 1969, 1983, Caughley 1970, Klein 1970, Houston 1982). Nutritionally stressed females tend to conceive and carry a pregnancy to term, but give birth to weakened young that succumb soon after birth, i.e., perinatal loss increases. Hence, cow:calf ratios are generally a better indicator of reproductive success than pregnancy rates. However, studies of populations of large ungulates typically utilize

pregnancy rates to assess reproductive success of select age classes, owing to the difficulty of obtaining age-specific cow:calf ratios. In addition, pregnancy rates for necropsied females are frequently reported relative to the females's last birthday, i.e., yearling pregnancy rates refer to 1.5-year-old animals, whereas in this study, calving rates of animals are reported relative to their most recent birthday, i.e., yearling pregnancy rates are expressed as calving rates for 2-year-olds.

Sexual Maturity--The ability to ovulate and conceive in female red deer (*C. e. elaphus*) is dependent upon achieving a critical carcass weight and body condition (Hamilton and Blaxter 1980, Mitchell et al. 1981). A similar pattern has been reported for free-ranging reindeer (*Rangifer tarandus*) (Leader-Williams and Ricketts 1982). Female elk at Point Reyes calved at their second birthday in 1981 and 1982. All calves born at Grizzly Island could be explained by monoparous births by 2+-year-old females, suggesting no calving by yearlings.

The single calf born to the Point Reyes population in 1980 must have been sired by a yearling male as four yearling bulls were the only males present during the rut. More than 90 percent of male yearling elk have been found

to be "physiologically capable of effective breeding" (Conoway 1952, Harper 1971). Another instance of female tule elk being successfully bred by yearling males was reported by Moffitt (1934).

McCullough (1969) reported three of four yearling tule elk females were pregnant. Houston (1982) reported a low pregnancy rate for yearling elk, ranging from 0-34 percent, that was negatively correlated with the severity of the previous winter and population density. A range of pregnancy rates from 0-40 percent for yearlings was reported for North American elk by Taber et al. (1982). Pregnancy rates reported for yearling red deer range from zero (Mutch et al. 1976, Caughley 1971b, Clutton-Brock et al. 1982) to 64 percent (Staines 1978).

Calving rate--Cow:calf ratios in the Point Reyes population declined precipitously from 1978 through 1980 and reached a peak in 1982 (Fig. 20). The low rates may be attributed to copper deficiency exacerbated by competition for forage with cattle (Chapter V). The 100 percent calving rate in 1982 indicates all adult females bore live calves (assuming no twinning), there being no females in the 2-year-old cohort. The cow:calf ratio in the Grizzly

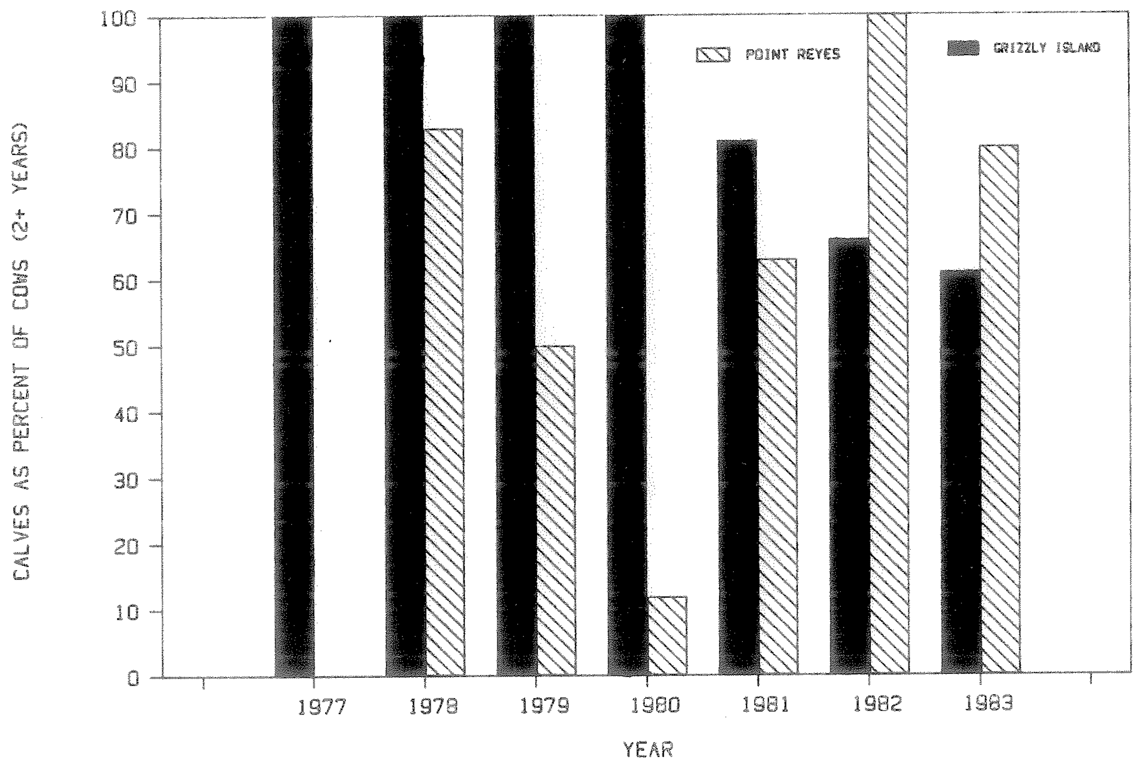

Figure 20. Calves as percent of cows in tule elk reintroduced to Point Reyes and Grizzly Island.

Island population was at 100 percent for the first 4 years following introduction, but declined in 1981 and thereafter. The ratio is negatively and significantly correlated with total population size (Fig. 21).

Pregnancy rates in red deer in Scotland are higher in females which did not have a calf at heel the previous fall (Mitchell et al. 1976, Mutch et al. 1976, Lowe 1969, Clutton-Brock et al. 1982). However, in the Point Reyes herd, two of seven adult cows failed to conceive or carry a calf to term in 1981 in spite of not being pregnant the previous year. The single adult cow calving in 1980 apparently aborted in April 1981. Calving rates increased in 1982 and remained high in 1983 (Fig. 20), suggesting females did not fully recover from copper deficiency and other nutritional stresses until the 1981 rut, or that sexual immaturity of 2-year-old males in the 1980 rut prevented impregnation of all females.

Twinning Rate--The production of nine calves by eight female elk at Point Reyes in 1978 (Ray 1981) is evidence of at least one set of twins. No information on twinning is available for the Grizzly Island herd. The incidence of twinning in C. elaphus is quite low. McCullough (1969) reported one case of twinning among 63 tule elk cows in the

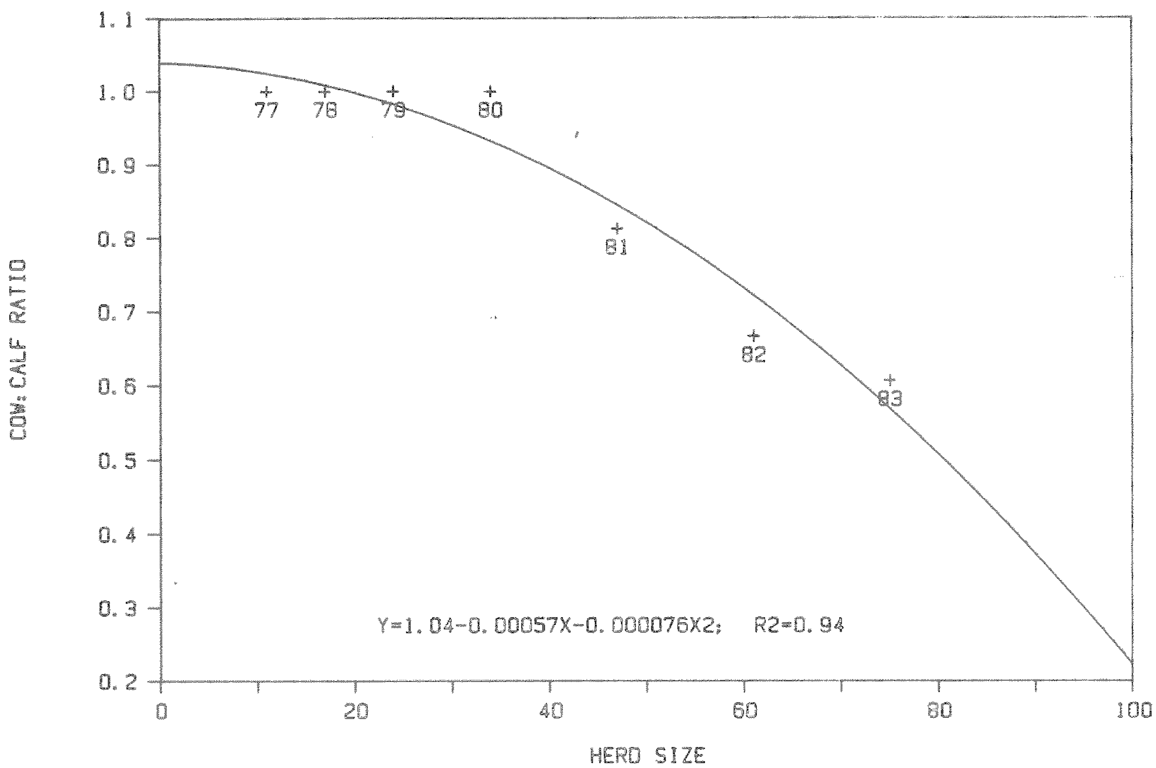

Figure 21. Relationship of cow:calf ratio to herd size in tule elk reintroduced to Grizzly Island.

Owens Valley. Twins were evident in less than one percent of more than 3,000 elk from the Yellowstone area, and this frequency did not vary with population size (Houston 1982:36). Rates of twinning in red deer have been reported as one in 600 (Mitchell 1973) and one in 140 (Mitchell et al. 1981).

Stillborn-Perinatal Loss--Measurement of cow:calf ratios in this study was completed by August 1 of each year, some 3 months after the beginning of the calving season. Observations prior to August 1 of the Point Reyes herd indicated some perinatal loss. Carcasses of two calves (unsexed) were recovered in 1978 (Ray 1981), and a stillborn calf (female) was dropped prematurely in 1981 (Gogan and Jessup 1985). In addition, an adult female possibly aborted 2 January 1981. A second adult female was suckling her 1980 calf on 1 April 1981, behavior indicative of having lost a calf. Thus, records for 1979, 1980, and 1981 suggest a rate of stillborn-perinatal loss of three (stillborns and perinatal losses) of 18 known conceptions (stillborn and perinatal losses plus surviving calves). Similar data are incomplete for the Grizzly Island population. Any perinatal loss between 1977 and 1980 could have been masked by twinning. Three calves (unsexed) were found dead in 1981 (Sohrweide, pers. comm.), suggesting

stillborn-perinatal loss of three of 16 calves for that year.

Some 64 percent of the tule elk calves born in the Owens Valley died within the first month of life (McCullough 1969). Eight of 13 calves born to a small herd of Roosevelt elk (*C. e. roosevelti*) died within the first week of life, and the following year nine of 14 calves born succumbed in their first month of life (Harn 1960, Harper et al. 1967). Nine of 56 red deer calves were stillborn or died soon after birth (Arman et al. 1978). Twenty percent of all calves born to red deer on Rhum died before the September of their year of birth, and nearly 80 percent of this mortality occurred within the first week of life (Clutton-Brock et al. 1982).

Sex ratio of calves--Female calves predominated in the Grizzly Island population while the sex ratio was equal in the Point Reyes population through 1982 (Tables 22 and 23). Only ratios of calves conceived and born at each location, i.e., not calves born in the year of introduction, were subjected to statistical tests. The sex ratio of calves did not differ significantly from a 50:50 ratio at Point Reyes (X^2 = 1.81, df = 1, P $\geq$ 0.05) or Grizzly Island (X^2 = 3.62, df = 1, P $\geq$ 0.05). Nor did

the sex ratios differ betwen populations (X^2 = 0.32, df = 1, $P \geq 0.05$). Houston (1982:46) reported a significant difference between the *in utero* sex ratio of fetuses (103 males:100 females; 1962) for the northern Yellowstone elk herd for a single year at high population density compared to a pooled sample for the following years (89 males:100 females; 1963-1968), during which the population declined. Clutton-Brock et al. (1982) found a preponderance of male offspring born to all red deer female age classes and no shift in the calf sex ratio as population density increased over time.

Studies of other species of cervids suggest offspring sex ratios are related directly to female nutritional level. Verme (1983) reviewed the literature for the genus *Odocoileus* and concluded does undernourished at conception produce a surplus of males. McCullough (1979) noted a shift in production toward female offspring in white-tailed deer (*O. virginianus*) following a reduction in density (and presumably an improved nutritional plane).

Population Stability

The tendency of a population to track or overshoot ecological carrying capacity (K) may be inferred from a

regression of rate of population change on population size. Only data for the Grizzly Island population were suitable for such an analysis (Fig. 22). A negative slope indicates a density dependent response. The point at which the regression line intercepts the zero rate of population change may be interpolated to obtain an estimate of average population size at K (McCullough 1978). The tendency of a population to track carrying capacity may be expressed by the formula (Maynard-Smith 1968):

$$L = bN_K \qquad (5)$$

where L is a measure of equilibrium tendency, b is the slope of the calculated regression, and N_K is the average population size at carrying capacity (the x intercept). L is equivalent to the y intercept of the linear regression slope (McCullough 1979). Values of L indicate the population's response to a varying carrying capacity: values of between zero and one suggest a tendency to overshoot, but oscillations dampen out to K, and values of greater than two suggest oscillations become greater in amplitude and lead to extinction. The value of 0.52 (Fig. 22) suggests the elk population at Grizzly Island will tend to track carrying capacity. McCullough (1978:312) calculated a value of 0.37 for tule elk introduced to the

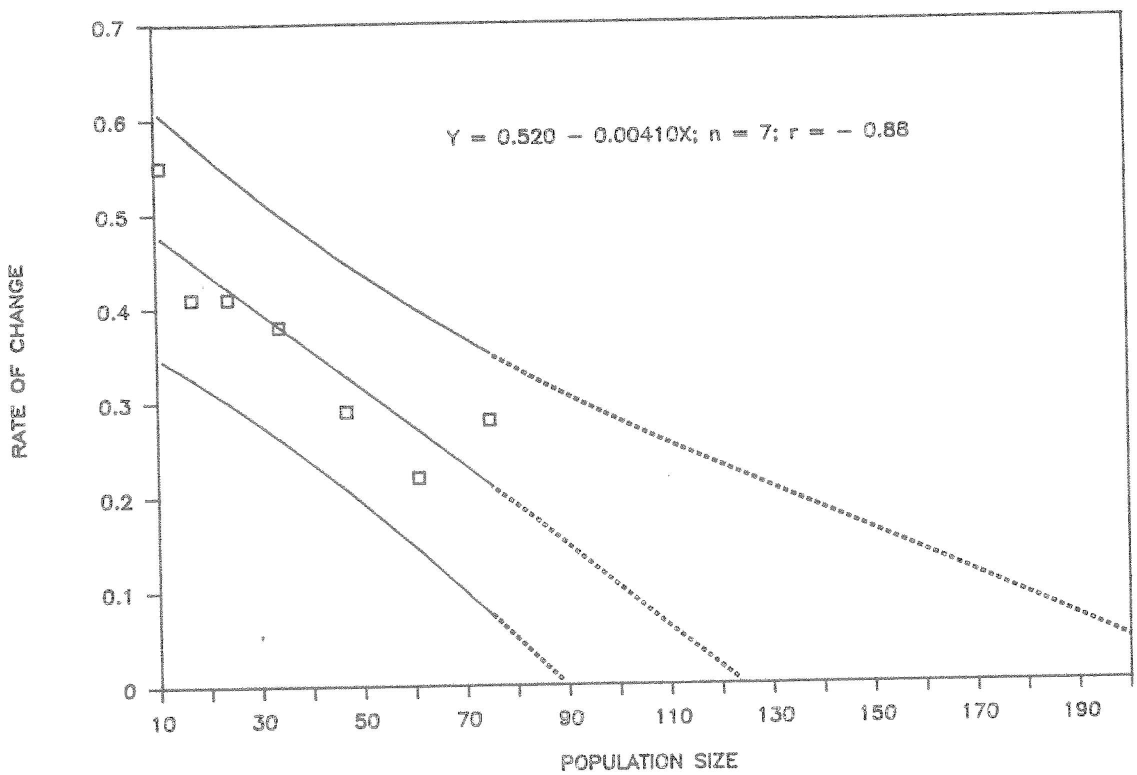

Figure 22. Regression and 95% confidence band of decline in the rate of population growth with increasing herd size in tule elk reintroduced to Grizzly Island (1978-1983).

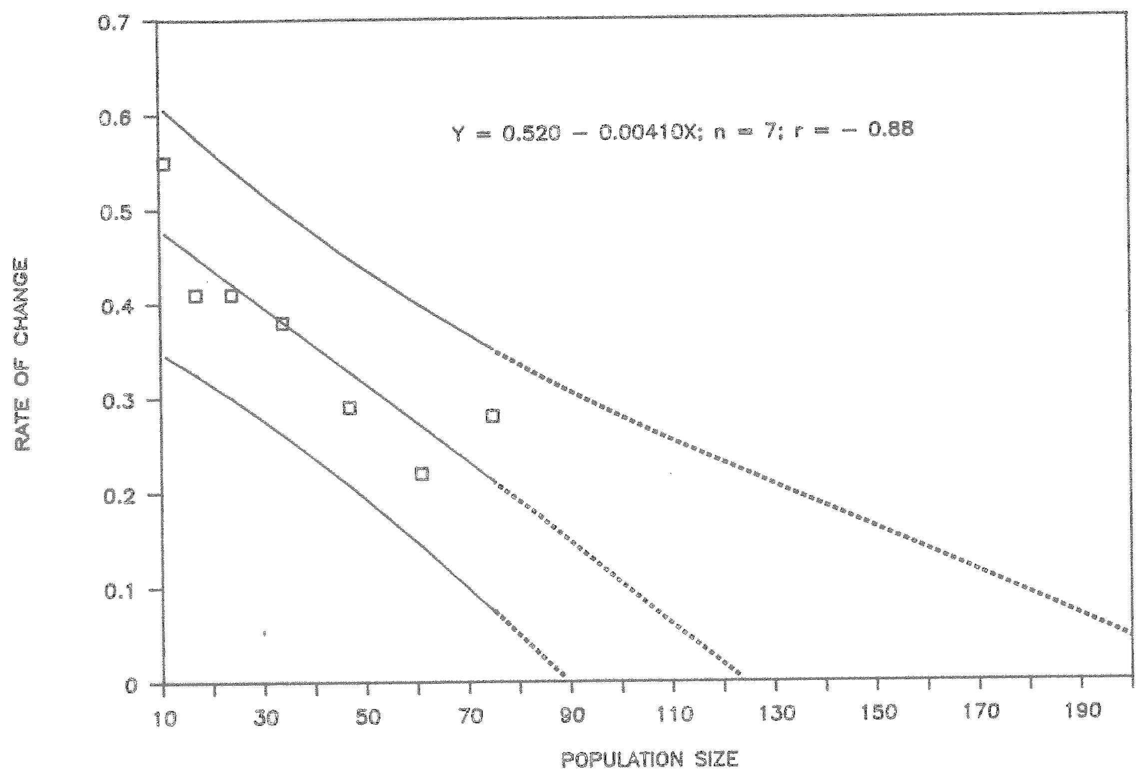

Figure 22. Regression and 95% confidence band of decline in the rate of population growth with increasing herd size in tule elk reintroduced to Grizzly Island (1978-1983).

Owens Valley based upon data for the first 34 years. The higher value for the Grizzly Island population may be considered a reflection of the population growing at virtually maximum rate, whereas the Owens Valley population grew at the far lower rate of $\hat{r}_m = 0.14$ for the nine years following introduction (McCullough 1978:313). Presumably, values of less than one for the Grizzly Island and Owens Valley populations suggest a similar value may be expected for the Point Reyes herd. Extrapolation of the linear regression to a rate of change of zero gives an estimate of carrying capacity of approximately 125 for the Grizzly Island herd (Fig. 22).

Time Lags

While elk populations show a tendency to track carrying capacity, there is little indication of how rapidly the tendency may be followed, i.e., the extent of a time lag before the population responds to a shift in carrying capacity. The 2 year delay in the increase in calving rates in the Point Reyes herd following the nutritional stress of copper deficiency and general malnutrition suggests time lags could be up to 2 years.

DISCUSSION

Caughley's (1970) review of ungulate introductions to previously unoccupied areas revealed a pattern of increase to high density and subsequent "crash" to a lower level. High numbers typically modify the vegetative cover to the extent it is no longer able to support numbers at the original level. While this outcome is common, it is by no means exclusive. Instances of introductions failing to expand have been documented. Two of 12 introductions of elk in Colorado failed (Swift 1945). Parasites of deer have caused the failure of introductions of elk (Severinghaus and Darrow 1976) and limited the growth rate of other elk populations (Hibler et al. 1969, Eveland et al. 1979).

The $\hat{r}_m$ of the tule elk population introduced to Point Reyes is the lowest recorded for a successfully introduced elk population over a comparable time period. In contrast, the $\hat{r}_m$ of the Grizzly Island population is exceeded only by Roosevelt elk introduced to Afognak Island. Tule elk introduced to Grizzly Island have grown in a pattern suggestive of the initial phase of the eruptive pattern described by Caughley (1976). However, it appears growth in tule elk at Point Reyes has been blocked by

density-independent environmental pressures attributable to high densities of cattle and black-tailed deer competing for forage and serving as a reservoir of disease.

Rapid population expansion might be expected when an ungulate population has available a standing crop of plant biomass in excess of needs for maintenance. The continued heavy grazing of domestic stock and high density of black-tailed deer at Point Reyes during California's 1976-77 drought and a year beyond the release of elk probably removed any surplus of forage likely to favor rapid expansion of elk numbers. Indeed, the animals were clearly nutritionally stressed by diet quality if not quantity (Chapter V).

Livestock at Point Reyes served as a reservoir of paratuberculosis leading to losses in elk born there (Jessup et al. 1981). The disease has had no reported effect on population growth of two exotic deer species on the Point Reyes Peninsula (Wehausen and Elliott 1982). There has been no direct contact yet between either exotic deer species and tule elk. Parasitism may affect the success of introduced populations of elk (Hibler et al. 1969, Severinghaus and Darrow 1976, Eveland et al. 1979). Elaephorosis is endemic in the black-tailed deer on the

Point Reyes Peninsula, and the black-fly vector is also common (R. Lane, pers. comm.). No incidence of this disease has been detected in Point Reyes elk to date. Although mountain lion are sighted occasionally at Point Reyes, no deaths among elk were due to predation.

The recent history of no ungulate grazing at Grizzly Island presumably resulted in the reintroduced elk there benefiting from an abundant standing crop of suitable forage. The absence of reservoirs of contagious disease and parasites protected this introduction from such factors.

The similarity of the $\hat{r}_m$ value for the Grizzly Island population and all other introductions except the overall $\hat{r}_m$ for Point Reyes (Table 24) suggests the pattern of growth at Grizzly Island is the maximal $\hat{r}_m$ possible. Rapid growth was achieved by advanced sexual maturity, high calving rates (up to 100 percent in 2-year-olds), low calf mortality, no juvenile mortality, low adult mortality, and possibly a calf sex ratio favoring females. A curvilinear pattern in cow:calf ratios (Fig. 21) suggests the influence of density-dependent factors will accelerate as the population approaches carrying capacity. Such a pattern is common in large mammal populations (Fowler et al. 1980),

although linear relationships also occur (McCullough 1979).

The initial $\hat{r}_m$ for Point Reyes elk was exceptionally low, reflecting density-independent environmental pressures. Slow growth was characterized by low calving rates, high subadult mortality, moderate adult mortality, and a 50:50 sex ratio among calves. However, the $\hat{r}_m$ at Point Reyes from 1981 to 1983 approximates the overall $\hat{r}_m$ of Grizzly Island suggesting these factors may have changed. Calving rates increased while subadult and adult mortality decreased after 1981.

Earlier attempts to model growth patterns of the Afgonak Island, Wichita Mountains, and Tyson Park introductions (Gross 1969) have assumed density-independent natality and mortality rates. Observations for the Grizzly Island population suggest such assumptions are not realistic. Eberhardt (1977) proposed the sequence of population processes effecting a response to density are: 1) juvenile morality rate; 2) age of sexual maturity; 3) natality rate; and 4) adult mortality rate. This appears to be the sequence at Grizzly Island. The presence of three perinatal losses and 13 live calves in 1981 indicates all 16 2+-year-old females calved that year. The decline in the number of live-born calves in 1982 and 1983 may

represent a combination of the first three factors. Natural mortality of adults in the Grizzly Island population was not observed until after August 1982. This variable is influenced by the age structure of the initial introduction.

The pattern of mortality in the Point Reyes population is atypical of nutritionally stressed populations. The initial pulse of mortality was among the introduced adults rather than the first cohort of calves. With the exception of a single female, calves in the first three cohorts surviving the first 3 months of life survived beyond their first birthday. The pattern of subadult mortality observed is due in part to the etiology of paratuberculosis, the chief cause of mortality. Although infected as calves, it requires a year or more before individuals become debilitated and succumb (Jessup et al. 1981). The decline in cow:calf ratios in 1979 and 1980 is consistent with a nutritionally stressed population. A low calving rate in two consecutive years suggests the elk did not recover from the nutritional stress causing adult mortality in 1978 for at least 2 years. The moderate calving rate for 1981 is due to a deformed, stillborn calf and possibly two abortions. The role of nutritional stress in these losses is unknown although inbreeding and teratogenic plants are

implicated in the case of the stillborn individual (Chapter VII, Gogan and Jessup 1985). High calving rates in 1982 suggest the Point Reyes population has begun a growth trajectory comparable to the Grizzly Island herd. The lack of adult mortality from August 1979 through 1983 in the Point Reyes population is indicative of the relaxation of density-dependent forces.

This analysis suggests the Grizzly Island population has an inherent tendency to track ecological carrying capacity, and one can assume the Point Reyes herd will also exhibit this trait. However, the existence of a time-lag in the response of elk to reaching carrying capacity, suggests both populations will exceed carrying capacity before stabilizing.

CONCLUSIONS

Differences in population parameters between tule elk reintroduced to Point Reyes and Grizzly Island reflect different environmental pressures on the two populations. Elk introduced to Grizzly Island were not restricted by environmental conditions. Elk introduced to Point Reyes suffered initial adult mortality and low reproductive success attributable to copper deficiency and subsequent

subadult mortality due to paratuberculosis. These factors greatly reduced the rate of population growth in elk at Point Reyes between 1978 and 1981.

CHAPTER V

COPPER DEFICIENCY IN TULE ELK

Tule elk reintroduced to the Point Reyes Peninsula in March 1978 received dietary supplements regularly for 6 months while being acclimatized in a 1.2 ha holding pen. They were released to the northernmost 1030 ha section of Tomales Point. The elk seemingly flourished while in the holding pen and for the first 3 months while free-ranging (Ray 1981), although the release site continued to be heavily grazed by beef cattle (0.4/ha) and black-tailed deer (0.3/ha). However, by the spring of 1979, the elk exhibited reduced reproductive success, deformed antlers, adult mortality, light-colored pelage and general lack of thriftiness. Discussions with local ranchers and a local veterinarian revealed cattle on Tomales Point regularly received dietary copper supplements to prevent potentially severe reproductive and calf survival problems, including birth of hairless calves with deformed spinal columns as was observed in the 1950's.

Supplementary feed, including copper and copper sulfate supplement, was provided daily to the surviving elk from mid-September 1979 until they ceased taking it in April

1980. Ranching operations were halted in November 1979, and all livestock and cross fencing removed.

Copper has been recognized as an essential trace element (Hart et al. 1928). It is absorbed in the duodenum and jejenum of monogastric and ruminant herbivores, binds to albumen in the plasma and is transported to the liver, where it is synthesized into ceruloplasmin, a single chain protein (Frieden 1979, Owen 1982). The liver stores ceruloplasmin and releases it into the blood as needed. Ceruloplasmin, which carries 88 percent of circulating copper in cattle (National Research Council 1977), is an enzyme essential in the oxidation of iron. It also delivers copper to various tissues to become components of specialized proteins (Frieden 1979).

Inadequate metabolic copper in herbivores may result from inadequate dietary copper (simple copper deficiency) or interactions of normally adequate copper levels with molybdenum and sulfide, resulting in reduced absorption of copper or interference with metabolic processes such as the role of copper in iron metabolism (complex copper deficiency) (Mills 1980).

Recognized clinical symptoms of the two forms in

domestic stock differ somewhat in their severity. Simple copper deficiency is characterized by loss of hair color (achromotrichia), anemia, ataxia, demyelination of the central nervous system, stiffness in the joints and abnormal gait, osteoporosis, spontaneous bone fracture, reduced reproductive capacity in adults, and poor growth rate of calves (Allcroft and Parker 1949, Cunningham 1950, Davis 1950, Owen 1981). Complex copper deficiency is marked by more severe symptoms as above, plus delayed and incomplete calcification of cartilaginous plates, and severe scouring (Allcroft and Parker 1949, Cunningham 1950, Irwin et al. 1974). Copper deficiency in wild ungulates has been reported as ataxia in adult red deer (C. e. elaphus) (Barlow et al. 1964, Terlecki et al. 1964), osteoporosis in adult reindeer (Rangifer tarandus) (Hyvarinen et al. 1977), and irregular hoof keratinization and reduced reproductive rates in adult moose (Alces alces) (Flynn et al. 1977). Copper deficiency may occur in a subclinical form characterized by low liver, blood and hair copper levels, but with individuals appearing normal and showing only marginal signs of poor health (Bingley and Anderson 1972, Thornton et al. 1972b).

Evidence of copper deficiency in livestock includes the symptoms described, but Hartmans (1973) considered analysis

of liver samples as most diagnostic of copper deficiency. He also noted that the average value for any element may be misleading with one or two values below the mean being more indicative of copper deficiency than the mean. Similarly, the high variation in copper levels in hair from cattle on the same diet makes it difficult to attribute low hair copper solely to low dietary levels (Hidiroglou and Spurr 1974). Furthermore, the proportion of a population exhibiting symptoms of copper deficiency may vary (Thornton et al. 1972a).

The purpose of this report is to relate levels of copper and molybdenum in tule elk at Point Reyes to levels in tule elk at four other locations in California and to three other cervid species at Point Reyes.

METHODS

Animal Samples

Four elk found dead were necropsied in the field, the second two carcasses being located within 24 hours of death. A fifth animal found dead and two destroyed after testing positive for paratuberculosis were transferred to the Wildlife Investigations Laboratory, Sacramento, or

School of Veterinary Medicine, University of California, Davis, for necropsy. Samples of liver, blood, and hair were obtained when possible.

Blood samples were obtained from elk transferred from San Luis Island to Point Reyes in the spring 1978. Surviving elk and those born at Point Reyes were immobilized with etorphine (4 mg) and xylazine (35 mg) (Jessup et al. 1981), and blood and hair samples taken at irregular intervals between August 1979 and April 1981. Sample sizes for tule elk at Point Reyes are relatively small in absolute terms -- three to seven -- for any sample period. However, the samples represent 30 to 38 percent of the total population, respectively. Samples of liver, blood and hair were obtained from four other tule elk populations (Concord Naval Weapons Station, Contra Costa Co.; Owens Valley, Inyo Co.; San Luis National Wildlife Refuge, Merced Co.; and Tule Elk State Reserve [Tupman], Kern Co.) and from animals restrained in the course of translocations or individuals presented to the Wildlife Investigations Laboratory for necropsy.

An extremely emaciated (10+ year) tule elk male was immobilized at Point Reyes in July 1979 and examined for evidence of microfilaria, eleophorosis and thelaziasis.

This individual was transferred to Grizzly Island State Wildlife Area, Solano Co., for nutritional therapy and observation. It was immobilized and sampled for blood and hair at irregular intervals between 1979 and 1981.

Hair samples were taken from exotic axis and fallow deer culled by National Park Service personnel within Point Reyes National Seashore. Black-tailed deer hair samples were taken from animals collected within the Seashore and from deer found dead on Tomales Point.

Copper levels in liver and serum were determined by atomic absorption spectrometry (Varian 475, Varian Co.). Molybdenum levels were determined by standard volumetric techniques at 470 Nm (Spec. 20, BNL Co.). These analyses were conducted by a commercial laboratory (California Analytical Labs, Inc.).

Hair samples from the first two elk to die on the range were submitted to the National Park Service's Materials and Ecological Testing Laboratory, Western Archeological Center, Tucson. All other hair samples were analyzed at the Department of Forestry and Resource Management, University of California, Berkeley. The samples were washed with ethyl ether and digested with tetramethyl

ammonium hydroxide (Flynn et al. 1977, Gross and Parkinson 1974). These digests were analyzed for copper by atomic absorption spectrophotometry.

A random subset of hair samples for the Point Reyes and Owens Valley elk populations were submitted to the Cooperative National Park Resources Studies Unit, University of California, Davis. Samples were ashed (dry) at 600° C. Molybdenum content was determined by the thiocyanate-stannous chloride method (Johnson and Arkley 1954).

Analysis of whole hair samples for all species rather than the two cm immediately above the hair follicle introduces variability associated with seasonal patterns of mineral deposition and increased variability in the pigmented portion of the hair (Flynn et al. 1975). This was compensated for somewhat by grouping samples only within, and not across, moult periods (summer vs winter coat), with one exception. In black-tailed deer, only two to three samples were collected each month between August 1979 and October 1980. These samples were simply pooled.

Plant and Soil Samples

A preliminary survey of trace element contents of soils and vegetation was done by National Park Service personnel in August 1979. A small number of samples of common soil types and plant species were collected throughout Tomales Point. Materials were submitted to the Materials and Ecological Testing Laboratory, Western Archeological Center, Tucson. Vegetation samples were digested by the nitric acid-hydrogen peroxide method (Gross and Parkinson 1974), slightly modified (Bennett, pers. comm.). Soil samples were extracted by shaking with diethylenetriamine-penta-acetic acid (DTPA) for 24 hours (Lindsay and Norvell 1978). Both the vegetative digest and soil extract were analyzed for copper and molybdenum by atomic absorption spectrophotometry (Yasuda et al. 1979).

More intensive sampling of soils and vegetation was undertaken in May 1981. Field sampling and laboratory methods have been described elsewhere (Akeson et al. 1982).

RESULTS

General symptoms of copper deficiency described for sheep and cattle were observed in the tule elk at Point

Reyes including: achromotrichia; rough and brittle pelage; stilted gait; spontaneous bone fracture; osteoporosis; scouring; reduced reproductive rates; and osteophagia. Two individuals had overgrown hooves similar to symptoms described for copper deficient moose (Franzmann et al. 1974).

Liver Trace Element Levels

The liver copper content of four tule elk dying at Point Reyes ranged from 1.9 to 10.0 ppm (DWB) (Table 25). Values for four, 6-month old tule elk calves from Concord exceeded 16 ppm (DWB), and the level for a single adult at Concord was almost nine times greater than the highest value from Point Reyes.

Normal levels in domestic ruminants range from 100-400 ppm (DWB) (Underwood 1977). Values for domestic stock experimentally maintained on copper deficient diets or diagnosed as copper deficient range between 5 and 25 ppm (DWB) (Allcroft and Parker 1949, Cunningham 1950, Hennings et al. 1973, Stoszek et al. 1979).

Liver copper values between 84 and 135 ppm (DWB) were recorded for tule elk at three locations (McCullough

Table 25. Copper and molybdenum values for liver samples (ppm, DWB) from tule elk from Point Reyes and Concord.

Location	Date	Age/Sex	Cu	Mo	Comments
Pt. Reyes	Nov. '80	2.5 yrs/male	1.9	<0.2	Natural death; succumbed to paratuberculosis.
Pt. Reyes	Aug. '79	Adult/female	3.1	5.4	Accidental death; osteoporosis; spontaneous fracture and osteophagy evident.
Pt. Reyes	Jul. '79	1 yr/female	4.7	5.0	Natural death; cause unknown.
Pt. Reyes	Nov. '79	1.5 yr/male	10.0	2.2	Accidental death.
Concord	Nov. '80	6 mo/female	16.0	<0.2	Accidental death.
Concord	Nov. '80	6 mo/male	16.0	<0.2	Accidental death.
Concord	Nov. '80	6 mo/female	17.0	<0.2	Accidental death.
Concord	Nov. '80	6 mo/male	21.0	<0.2	Accidental death.
Concord	Sept. '79	Adult/female	88.2	1.6	Accidental death.

1969:123). Values for elk (*Cervus elaphus* spp.) in Fiordland National Park, New Zealand, averaged 69 ppm (DWB), while free ranging red deer (*C. e.* spp.) outside the park averaged 132 ppm (DWB) (Reid et al. 1980). The average value for red deer from captive herds in the same region, with some evidence of ataxia, was 11 ppm (DWB) (Reid et al. 1980). Female red deer (*C. e. elaphus*) in Scotland had an average level of 24 ppm with a range of 3-108 ppm (DWB) (Cowie 1976). Ataxia has been reported in red deer populations in the British Isles (Barlow et al. 1964, Terlecki et al. 1964), and liver copper values for one such population were 7-17 ppm (DWB) (Terlecki et al. 1964:317).

Liver molybdenum values for tule elk at Point Reyes were highest in July and August 1977, (Table 25), and slightly lower in November 1979. A November 1980 sample from Point Reyes and four samples from Concord were below the value of 0.2 ppm (DWB) detectable by the analysis. Liver molybdenum levels of 3.4 to 4.5 ppm (DWB) were recorded for tule elk at three other sites (McCullough 1969:123).

Serum Trace Element Levels

Comparison of serum copper levels in tule elk sampled

at San Luis Island in March 1978, at the time of transfer to Point Reyes, and six subsequent sampling periods at Point Reyes show serum copper levels in tule elk at Point Reyes were below 1 ppm in the summer 1979, and fall and winter 1981, prior and subsequent to the period of copper diet supplementation (Fig. 23). Small sample sizes preclude statistical comparison. Samples from other tule elk populations for the fall of 1978 and 1979 (Table 26) are generally comparable to the fall of 1979 through summer 1980 samples from Point Reyes and the spring 1978 sample from San Luis Island. Serum copper values for reindeer exhibiting no signs of nutritional stress were 1.2 ppm in contrast to levels of 0.4 ppm in a herd diagnosed as copper deficient (Hyvarinen et al. 1977:651).

Serum molybdenum values are available only for tule elk at Point Reyes (Fig. 23). Sample sizes are too small to warrant statistical comparison. Molybdenum levels were at a low in fall 1979 and rose markedly by summer 1980.

Hair Trace Element Levels

Hair samples from the two mortalities at Point Reyes in May and June 1979 had the lowest copper values recorded for any sample (Fig. 24). Hair copper in Point Reyes elk

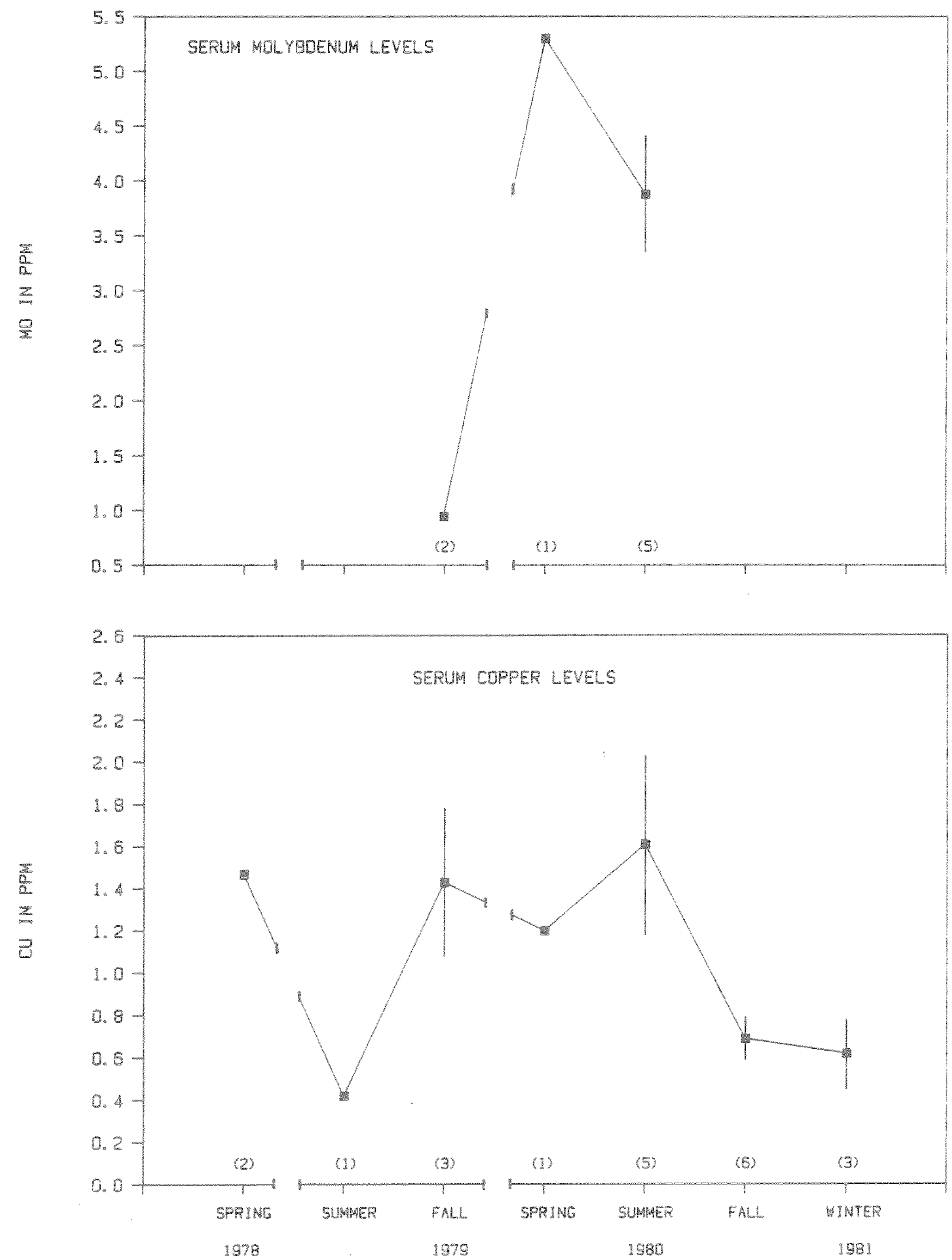

Figure 23. Serum copper and molybdenum levels (ppm) in tule elk at Point Reyes. Vertical bars are standard error. Sample sizes given in parentheses.

Table 26. Serum copper levels (ppm) for tule elk at locations other than Point Reyes in the fall of 1978 and 1979 combined.

Location	N	$\bar{x}$	SE
Concord	3	1.73	0.25
Tupman	2	1.40	-
Owens Valley	8	1.47	0.09

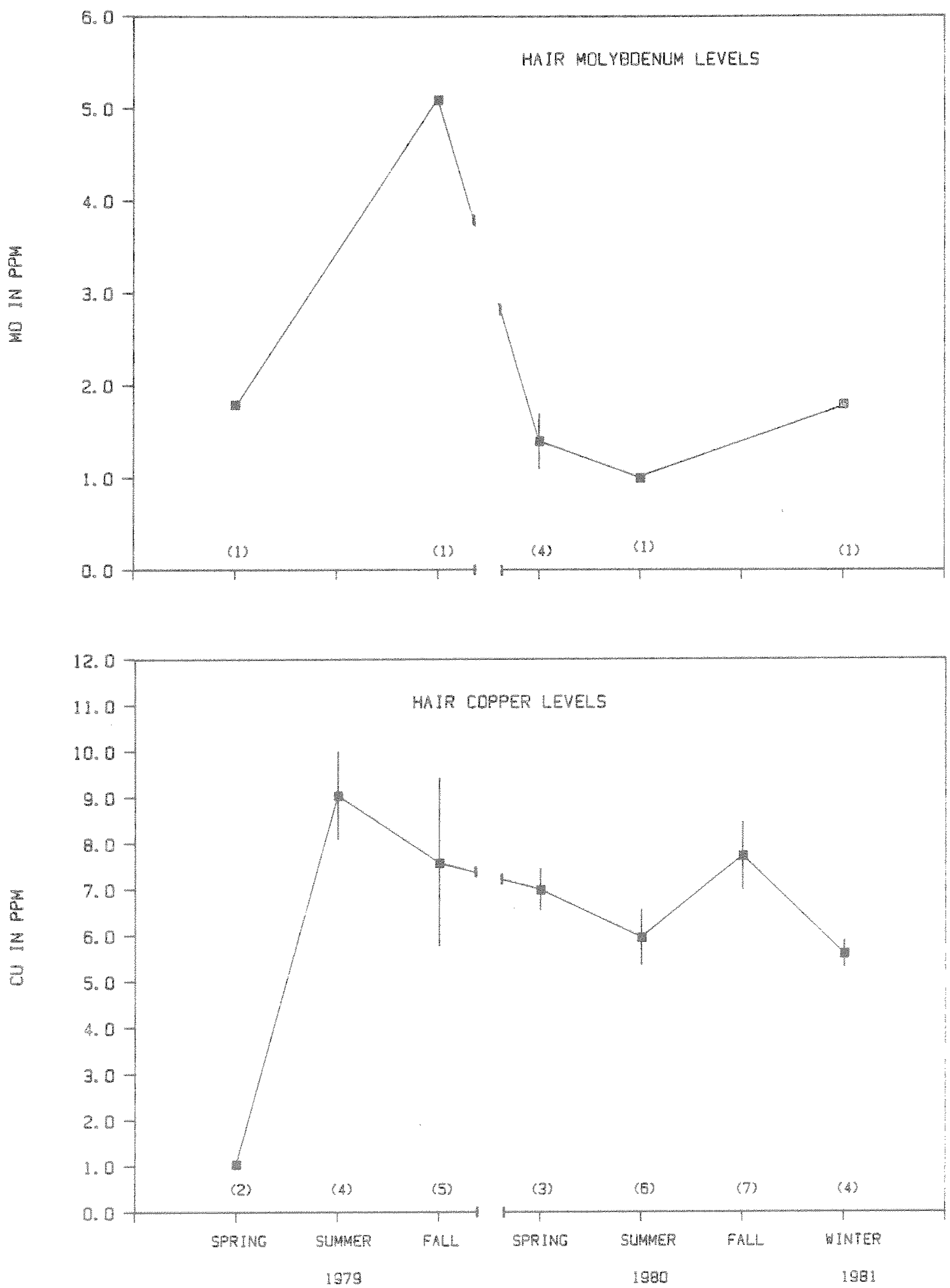

Figure 24. Hair copper and molybdenum levels (ppm, DWB) in tule elk at Point Reyes. Vertical bars are standard error. Sample sizes given in parentheses.

reached a high in summer 1979 and declined through winter 1980.

Comparison of levels in Point Reyes elk to other tule elk populations at approximately the same time (fall 1979-1981) shows the values for the Point Reyes population were consistently lower than those for three other populations (Table 27). Moreover, the values for each tule elk sample were consistently lower than those for three other cervid species on the Point Reyes Peninsula.

Monthly copper values for moose on the Kenai Peninsula, Alaska, range from a high of 14.7 ppm in October to a low of 1.4 ppm in December (Franzmann et al. 1975, 1977). A value of 7.9 ppm in April was considered indicative of copper deficiency, especially in comparison to a comparable value of 14.6 ppm for moose from Saskatchewan (Franzmann et al. 1977). Moose of the Kenai Peninsula exhibiting deformed hooves as a symptom of acute copper deficiency had mean hair copper levels of 5.7 ppm while those without deformed hooves had mean values of 12.0 ppm (Franzmann et al. 1974).

Hair molybdenum samples for tule elk from Point Reyes were below 2 ppm (Fig. 24) in the spring of 1979 and 1980.

Table 27. Hair copper and molybdenum levels (ppm, DWB) for tule elk at locations other than Point Reyes and for deer species at Point Reyes.

		Copper			Molybdenum		
Species	Location	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Tule elk	Concord	7	10.8	0.96	-	-	-
	San Luis	19	8.3	0.50	-	-	-
	Owens Valley	50	12.9	0.93	8	4.9	0.65
Fallow deer	Point Reyes	14	8.4	0.83	-	-	-
Axis deer	Point Reyes	16	11.2	0.56	-	-	-
Black-tailed deer	Point Reyes	18	8.8	0.56	-	-	-

A sample from Point Reyes in the fall of 1979 approximates values from the Owens Valley in the fall of 1980 (Table 27).

Individual Variation Over Time

The tule elk male transferred to Grizzly Island was isolated in a holding pen and provided copper supplemented feed for approximately 6 months prior to release at Grizzly Island. Tests for microfilaria, eleophorosis and thelaziasis at the time of relocation were all negative. The hair copper value for July 1979 (Table 28) exceeds the minimal guideline for hair samples of 8 ppm (Franzmann et al. 1977), in spite of the emaciated appearance and overgrown hooves of this individual. The increase in hair copper levels in November 1979 suggests a rapid response to nutritional therapy. Subsequent declines in hair copper levels likely reflect cessation of copper supplementation. The serum copper level at Point Reyes in July 1979 is probably more indicative of the nutritional stress of this individual than the hair copper level. Serum copper reached a high for this animal in May 1980. By July 1980 copper deficiency resumed.

Table 28. Copper and molybdenum levels (ppm) in multiple serum and hair samples from an adult male elk transferred from Point Reyes to Grizzly Island.

Date	Location	Serum		Hair	
		Cu	Mo	Cu	Mo
Jul. '79	Point Reyes	0.3	-	9.5	-
Nov. '79	Grizzly Island	-	-	11.8	-
May '80	Grizzly Island	1.0	4.0	3.6	-
Jul. '80	Grizzly Island	0.3	3.0	6.2	-

DISCUSSION

Copper levels in liver, serum and hair samples suggest tule elk at Point Reyes were deficient in this trace element during the summer of 1979. Liver copper levels for the three animals sampled in 1979 are well below the normal range reported elsewhere for elk (McCullough 1969, Reid et al. 1980) and approximate values for red deer populations considered deficient (Reid et al. 1980, Terlecki et al. 1964).

The low levels of liver copper for the four 6-month-old calves from Concord, in comparison to the adult from that site and adults from the Owens Valley (McCullough 1969), suggest liver copper levels increase with age. Such a pattern has been reported in sheep with adult liver copper values considerably higher than those for lambs (Cunningham 1950). However, work with red deer (Reid et al. 1980) and cattle (Cunningham 1950) shows liver copper levels were higher in the fetus/neonate than in adult.

Serum copper levels in Point Reyes tule elk were lower in the summer 1979 than at any other time. Values for the fall 1980 and winter 1981 are only slightly above the summer 1979 samples. The higher values for the fall 1979

through summer 1980 correspond approximately with the period of dietary copper supplementation. A level of less than 1 ppm is comparable to values for copper deficient moose (Flynn et al. 1977), reindeer (Hyvarinen et al. 1977), and cattle (Hennings et al. 1973).

Similarly, hair copper levels were far lower in spring 1979 than in later sampling periods. Mean values for elk at Point Reyes were below the critical value of 8 ppm (Franzmann et al. 1977) in all periods except the summer 1979. Mean values for other tule elk populations and for other cervid species on the Point Reyes Peninsula were consistently higher than this critical value.

Higher hair copper levels in the three other cervid species on the Point Reyes Peninsula may be attributable simply to intergeneric differences in copper deposition. Ataxia was not recorded in fallow deer sharing the range with copper deficient red deer (Terlecki et al. 1964). However, environmental factors may also play a role. Fallow and axis deer, both grazers, range over portions of the Point Reyes Peninsula south of Tomales Point where most soils are derived from marine sediments, rather than from the granitic bedrock providing the parent material on most of Tomales Point (Galloway 1977). Grasses at Tomales Point

tended to be lower in copper content than forbs or browse. Elk take forbs and grasses (Chapter XIII). The preference of black-tailed deer for forbs and browse may have contributed to the higher hair copper levels in this species.

There is no evidence of an annual cycle of serum or hair copper levels in tule elk at Point Reyes. The sampling frequency may not have been great enough to detect any such pattern, or the copper balance in tule elk at Point Reyes may have been so severely disrupted through 1979-1981 that no annual cycle occurred. Copper-rich diet supplements may have masked any annual cycle in serum copper levels. Seasonal changes in serum copper content have been reported in reindeer (Hyvarinen et al. 1977) and sheep (Howell et al. 1968), and for plasma copper levels in cattle (Gomm et al. 1982). Peak levels in female reindeer (Hyvarinen et al. 1977) and sheep (Howell et al. 1968) are reached at the time of parturition. Calving in tule elk at Point Reyes occurs in April and May. None of the serum samples coincide with that time. Also, only three live-born calves were observed in 1979, and only one in 1980 (Chapter IV). Any increase in serum copper levels in post-partum females may not have been detected by failing to sample these few animals.

Diagnosis of copper deficiency in tule elk at Point Reyes was confounded somewhat by a concurrent outbreak of paratuberculosis (Jessup et al. 1981). All cases of scouring were in individuals ultimately diagnosed as positive for paratuberculosis. The complexity of interaction between paratuberculosis and copper deficiency is not known. Cattle with paratuberculosis have been shown to be deficient in magnesium, not likely caused by the disease (Stewart et al. 1945). Samples from animals ultimately diagnosed as positive for paratuberculosis were excluded from the calculations of copper serum and hair levels.

The method of analyzing hair samples utilized the entire hair shaft rather than the proximal 2 cm as in other studies (Flynn et al. 1975). The latter have demonstrated two to three-fold differences in seasonal hair copper levels in moose (Franzmann et al. 1975, 1977). No such pattern was evident in tule elk at Point Reyes.

Pregnant female elk are entering their third trimester of pregnancy and males begin to grow new antlers in the spring. Presumably, both activities require high levels of copper. The absence of evidence of annual cycles in serum and hair copper levels from mid-1979 through early 1981 may

be indicative of a chronic copper deficiency in this population.

In cattle, the daily requirement for copper increases by approximately 70 percent of the maintenance requirement during the third trimester of pregnancy (Agricultural Research Council 1980), and the liver copper content of pregnant cattle declines once the fetus is older than approximately 190 days (Pryor 1964). Such high demands for copper during pregnancy may explain the drop in reproductive rates characterizing domestic stock suffering copper deficiency and tule elk at Point Reyes in 1979 and 1980. A peak demand for copper in the spring may have been a contributing cause of death in the two adult elk dying at Point Reyes in May and June 1979.

Serum copper levels in the Point Reyes tule elk were low for more than a year beyond the time severe copper deficiency was noticed, although none of the external symptoms observed in 1979 were evident in 1980-1981. These chronically low levels suggest tule elk at Point Reyes may have a subclinical copper deficiency (Bingley and Anderson 1972, Thornton et al. 1972b). Any relationship between copper and molybdenum levels is unclear. Serum molybdenum content is higher than serum copper content for one of the

two sample periods (Fig. 23). The high level in July may be caused by ingestion of large quantities of miner's lettuce (*Montia perfoliata*). This succulent species is rich in molybdenum (Akeson et al. 1982) and constituted more than 20 percent of the elk diet in May 1980 and up to 75 percent of the diet in April 1981 (Chapter XIII).

The potential of molybdenum to interfere with copper uptake has been recognized for some time, and molybdenum is frequently administered as a preventative to stock suffering from hypercuprosis. A number of workers have proposed an absolute amount of molybdenum or a molybdenum:copper ratio above which copper deficiency is to be expected in livestock. Such values are subject to constant revision as studies are conducted in different areas.

The role of sulfur in interfering with copper uptake has been recognized more recently. Work with sheep presented diets differing in molybdenum and sulfur contents within the ranges 0.5-15 ppm molybdenum and 0.8-4.0 g/kg sulfur showed the true availability of copper (A) to be highly correlated ($r = 0.93$) with dietary concentrations of sulfur (S) (g/kg DM) and molybdenum (Mo) (mg/kg DM). The relationships may be expressed by the equation (Suttle and

McLaughlan 1976:22A):

$$\log(A) = -1.153 - 0.076(S) - 0.013(S \times Mo). \qquad (6)$$

Thus, sulfur exerts an effect upon the availability of copper independent of and greater than molybdenum. The validity of the equation in predicting copper availability has been confirmed (Agricultural Research Council 1980). A similar relationship for cattle is:

$$y = 1.03(\pm0.17) + 2.86(\pm0.59)X \quad (R = 0.86), \qquad (7)$$

where X = dietary copper (mg/kg dm) x (A) and y = daily change in hepatic copper content (mg) (Agricultural Research Council 1980:228). The equation is likely to break down at levels of dietary molybdenum between 40-50 mg/kg (Agricultural Research Council 1980).

Such equations explain average liver copper levels of 23 ppm (DWB) in cattle fed fescue (Festuca arundinacea) with mean copper, molybdenum and sulfur values of 6.6 ppm, 2.3 ppm and 0.34 percent, respectively, in contrast to average liver copper values of 102 ppm in cattle on a diet of quackgrass (Agropiron repens) with comparable values of 4.6 ppm, 1.2 ppm, and 0.16 percent, respectively (Stoszek

et al. 1979). Similarly, copper deficiency in moose has been explained more fully by the product of the levels of sulfur and molybdenum in hair samples than by either value separately (Flynn et al. 1976).

However, total molybdenum content of a plant is not indicative of its impact on ruminant nutrition. The high levels of molybdenum relative to copper in cured plant material in the fall may not be indicative of molybdenum induced copper deficiency in tule elk at Point Reyes. The level of molybdenum in succulent miner's lettuce in the spring may have more of an impact on copper levels. Studies have shown the expression of copper deficiency in domestic stock is less severe when the diet is changed from wet to dry or cured vegetation of the same species composition. This change was associated with a reduction in molybdenum in the water soluble component of the forage despite little change in total molybdenum (Ferguson et al. 1943).

Copper may be directly available to the ruminant from ingested soil (Healy et al. 1970, Thornton 1973). Both domestic and wild ungulates have been observed ingesting soil voluntarily, and involuntarily with forage. Ingested soil may constitute up to 10 percent of the dry matter

intake of sheep and cattle (Field and Purves 1964, Thornton 1973). However, addition of three types of soil at a level of 10 percent of the dry matter in the diet of sheep reduced copper uptake by a minimum of 50 percent (Suttle et al. 1975).

CONCLUSIONS

Tule elk at Point Reyes are susceptible to simple copper deficiency resulting from inherently low levels of copper in parent materials, soils and forage. Copper deficiency probably occurred in a subclinical form in the fall 1980 and winter 1981 and was possibly exacerbated in the spring by high levels of sulfur and water soluble molybdenum in the vegetation. Likely, spring is a time of peak metabolic demand for copper in both sexes of adult tule elk. The symptoms of severe copper deficiency were first evident in the spring 1979.

CHAPTER VI

PARATUBERCULOSIS IN TULE ELK

Two elk born at Point Reyes in 1978 began to exhibit emaciation, severe diarrhea and fecal pasting of the hocks in March 1980. Such symptoms characterize paratuberculosis. The disease has been identified in livestock and free-ranging exotic fallow and axis deer on the Point Reyes Peninsula (Riemann et al. 1979a). Most information on the disease comes from domestic stock. However, it has been identified in a variety of wild ungulate species under captive conditions (Jessup et al. 1981), as well as free-ranging bighorn sheep (*Ovis canadensis*) and mountain goat (*Oreamnus americanus*) (Williams et al. 1979).

Paratuberculosis is caused by *Mycobacterium paratuberculosis*, a small rod-shaped, acid-fast bacillus that is a primary pathogen of the digestive tract (Larsen 1972). Passage of bacteria in feces is the most common source of infection, and the bacteria may remain alive in the soil up to 1 year (Larsen 1972). The organism may also be transmitted *in utero* and in cattle has been isolated from the uterus, fetus, mammary glands and testes (Thoen and Muscoplat 1979).

Symptoms of the disease include brittle pelage, emaciation and severe scouring (Bruner and Gillespie 1973). In some instances, death resulted. The symptoms resemble those associated with copper deficiency identified in the tule elk herd in 1979. The bacteria centers in the lower end of the small intestine and associated lymph nodes of the mesentery and causes lesions of the intestinal wall characterized by a proliferation of masses of epitheloid cells and in the lower layers of the mucosa and submucosa (Bruner and Gillespie 1973).

METHODS

All elk on Tomales Point were located and observed at least twice each week from July 1979 through August 1981 and monthly through July 1984. Color-coded and numbered ear tags permitted individual identification. Observations were less frequent since that time.

Twelve elk were immobilized with dart-syringe administered etorphine (4 mg) and xylazine (35 mg) (Jessup et al. 1981) and blood and fecal samples obtained between April 1980 and January 1981. Freshly deposited fecal material was obtained from elk showing severe scouring between March 1980 and January 1985. Laboratory procedures

have been described by Jessup et al. 1981.

RESULTS

A male and female of the 1978 cohort born to adult females pregnant at the time of relocation began to lose weight and scour in March 1980, at approximately 22 months of age. The condition of both deteriorated steadily, until by May 1980 they were no longer able to keep up with the main herd and were frequently sighted as solitary individuals. The male died in November 1980. The female rejoined the main group upon occasion through March 1981, when she was destroyed. Both animals tested positive for paratuberculosis.

A female born in 1979 to a cow introduced to Point Reyes as an adult in 1978 began to lose weight while suckling her first calf in June 1979, at approximately 2 years of age. A fecal sample tested positive for paratuberculosis. She rejoined the herd before being destroyed in July 1981. The calf at heel (1981 cohort) survived the sudden and early weaning and was observed with the cow:calf herd until April 1982. At this time she was solitary and exhibiting the clinical symptoms of paratuberculosis. She was never relocated and probably

died of paratuberculosis.

A male of the 1981 cohort, born to an adult female of the original introduction, was observed exhibiting symptoms of paratuberculosis in December 1984, at 2.5 years of age, while in association with apparently healthy males. It tested positive for paratuberculosis and was destroyed in January 1985.

_M_. _paratuberculosis_ was recovered from the feces of all clinically affected elk as well as from an elk which appeared normal. The internal pathology of the disease in tule elk (Jessup et al. 1981) closely resembles that for domestic stock (Bruner and Gillespie 1973).

Five of seven instances of mortality recorded in Point Reyes tule elk between 3 months and 3 years in age are attributable to paratuberculosis. There have been no clinical cases of paratuberculosis in adult tule elk reintroduced to Point Reyes.

DISCUSSION

Paratuberculosis was most likely transmitted to tule elk from livestock while both shared the range in 1978 and

1979. Bacteria-laden feces are the primary source of infection, and the bacillus may remain viable in the soil up to 1 year (Larsen 1972). Intrauterine infection may also occur (Thoen and Moscuplat 1979). Cases of paratuberculosis in elk born at Point Reyes some 19 months after removal of livestock suggest three possible means of transmission: 1) cattle-elk transmission through viable bacilli in the soil; 2) elk-elk transmission via bacilli shed in feces or _in utero_ transmission; or 3) black-tailed deer-elk transmission through bacilli shed in feces. The disease is present in two species of exotic deer on the Point Reyes Peninsula, but their ranges do not overlap that of the tule elk. There are no records of paratuberculosis in black-tailed deer at Point Reyes, but there is little reason to believe it has not been transmitted to them given the wide range of ungulates for which it has been recorded (Jessup et al. 1981), including other cervids at Point Reyes.

Cattle do not normally show symptoms of the disease until two- or three-years old. Symptoms in tule elk were diagnosed from 11 through 30 months. Four responses to exposure are possible (Larsen 1973): 1) clinical illness and shedding of bacteria; 2) no external symptoms but shedding (subclinical); 3) infection without clinical

symptoms or shedding detectable quantities of bacteria; and 4) no infection.

The disease has been detected in slightly less than 10 percent of the cattle (clinical and subclinical) and both exotic deer species (subclinical only) on the Point Reyes Peninsula (Riemann et al. 1979b). It has occurred in five of the 16 tule elk born at Point Reyes between 1978 and 1981. However, two of the 16 died of other causes prior to an age paratuberculosis is likely to become evident. These two elk may have been infected with paratuberculosis. Thus, the frequency of the disease may be better expressed as five of 14 or 16 individuals.

The impact of nutritional stress on the epidemiology of paratuberculosis is not clear. In cattle, most cases appear in two- or three-year-old females and often become evident while the cows are under the nutritional stress of lactation (Bruner and Gillespie 1973). There was no significant difference between sexes in the incidence of paratuberculosis in either exotic deer species on the Point Reyes Peninsula (Riemann et al. 1979b). Three of the five cases in tule elk were in females. Four of the five cases were initially observed in late winter, while the fifth occurred in early winter. Only one of the three females

was lactating at the time clinical symptoms became evident. One of the other females was barren. The status of the 11-month female is unknown. The late winter and early spring may be a period of nutritional stress in both elk sexes; females are in the last trimester of pregnancy and males are growing their new antlers.

There is some suggestion that the incidence of paratuberculosis may be affected by edaphic factors. In the Netherlands a higher incidence of the disease has been observed in cattle on lower pH soils than high (Jansen 1948), suggesting the bacillus has differential survival relative to soil pH. Also, cattle with paratuberculosis have been shown to be deficient in magnesium, not likely caused by the disease (Stewart et al. 1945). Both soil pH and trace element levels may influence the incidence of paratuberculosis in tule elk at Point Reyes. Soils of the tule elk range are acidic (Soil Conservation Service 1967), and the elk are copper deficient. Copper levels were not examined in the previous study (Stewart et al. 1945), and magnesium levels were not investigated in this study.

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CONCLUSIONS

Transmission of paratuberculosis to tule elk on Tomales Point was likely from beef cattle sharing the range for 1.5 years after the elk were relocated. Establishment of the disease may have been facilitated by edaphic factors and consequent trace element deficiency in the elk. Losses among subadult elk due to paratuberculosis during low population numbers have slowed population growth. Paratuberculosis is a highly infectious disease with the potential to cause losses in both domestic and wild ungulates. Its presence in tule elk on Tomales Point precludes any opportunity to relocate elk from Point Reyes to other locations.

CHAPTER VII

CLEFT PALATE IN A TULE ELK CALF

Reduced reproduction and recruitment in tule elk reintroduced to Point Reyes National Seashore severely limited growth in the population (Chapter IV). Causes of mortality in fetuses or neonates are frequently difficult to determine because of the secretive nature of females near parturition and the rapid disappearance of carcasses of young in the wild.

METHODS

A 3-year-old female born at Point Reyes in 1978 was sighted alone at 1810 hours on 8 May 1981 and observed until 2030 hours, at which time observations were discontinued. The female spent the entire period in sternal recumbancy and frequently licked her perineum and immediately behind her rear legs. The bedding site was examined at 0700 hours on 9 May. The female had left the area. The carcass of a calf, but no placenta, was found at the site. The carcass was immediately transported to the Wildlife Investigations Laboratory, California Department of Fish and Game, for necropsy. The skull was deposited at

the Museum of Vertebrate Zoology, University of California, Berkeley (MVZ 169021).

RESULTS

The 9.5 kg carcass was that of a female, approximately 20 days premature as determined by size. Four live-born calves captured within a week of birth in 1981 weighed an average of 15.3 kg (S.E. = 0.95). McCullough (1969) reported a mean weight of 13.0 kg for six tule elk calves. The umbilicus had been chewed off at the abdomen with no evidence of hemorrhage. The foot pads were unworn. There were no external lesions. The ductus arteriosus was patent. Fetal circulation to the umbilicus and hepatic portal vein were intact. The lungs were atelectatic and did not float in fluid. All other tissues and organs appeared normal. There were small reserves of subcutaneous, perirenal, mesenteric and cardiac fat.

Examination of the skull showed that the first and second incisors were symmetrical but had not migrated into full-term position. The incisive bones deviate to the right as a result of a failure of the right maxillary and right palatine bones to form and fuse at the midline with those same bones on the left side (Fig. 25). As a result,

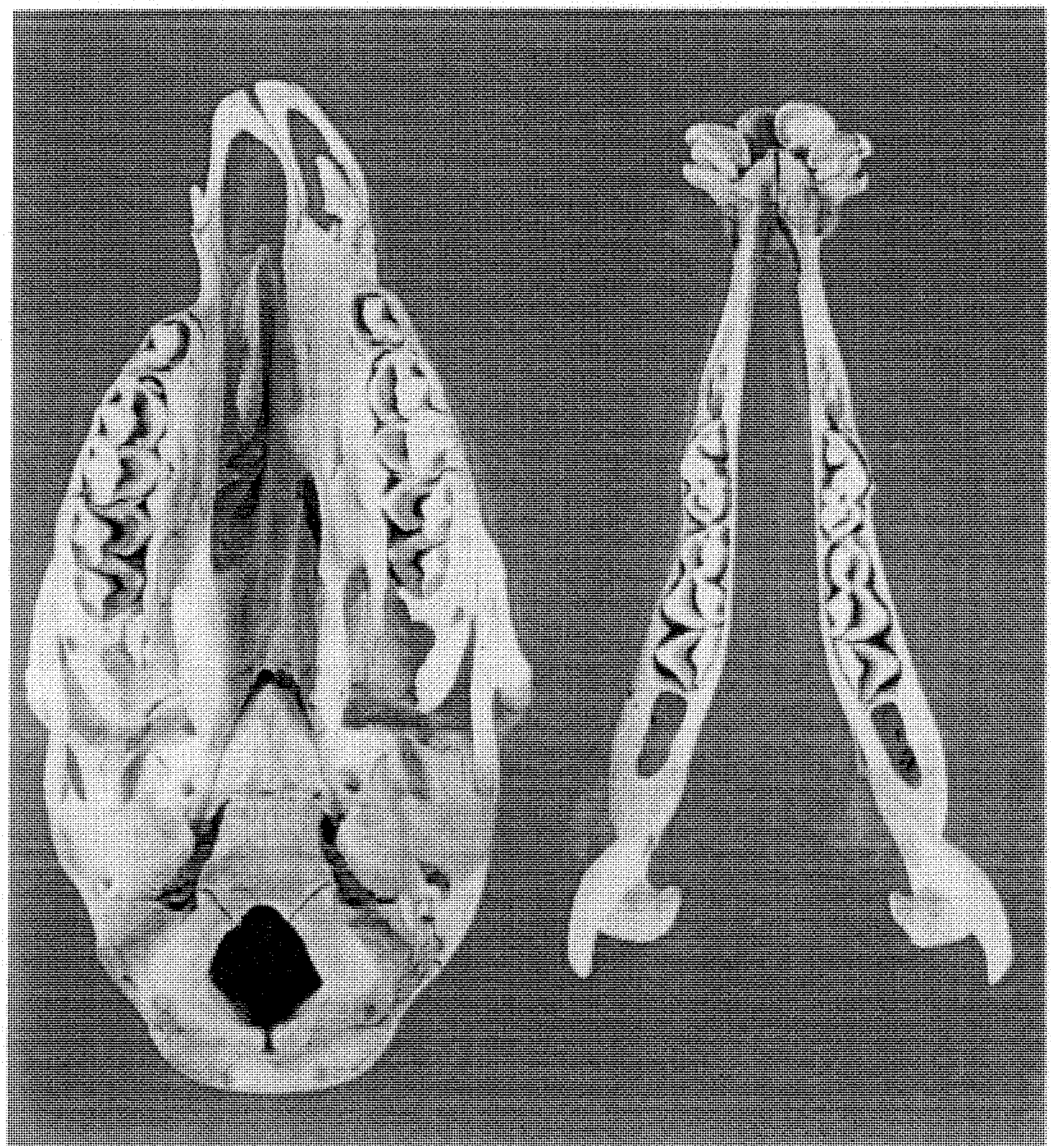

Figure 25. Photograph of a skull of a premature tule elk fetus showing cleft palate. Photo by Jerald Morse.

the hard palate was absent on the right side of the skull, the nasal cavity being open to the oral cavity.

DISCUSSION

Congenital deformities in cattle occur in 1-3 percent of all births (Leipold 1978). Cleft palate is common in domestic stock (Runnells et al. 1965). The few documented accounts of cleft palate in free-ranging cervids are undoubtedly due in part to the nearly always fatal outcome of the affliction and the rapid disappearance of the remains of neonates under field conditions. No published accounts of cleft palate in elk were found. Non-fatal brachygnathia inferior has been observed in tule elk at the Tule Elk State Reserve, Kern Co., California. Tule elk at Point Reyes are descended directly from those at the state reserve.

A case of cleft palate in an adult male white-tailed deer (*Odocoileus virginianus*) has been reported (Dahlberg and Guettinger 1956). Similarly, cleft palate was among a number of congenital abnormalities reported in black-tailed deer in Tillamook Co., Oregon; five of 16 does dropped or carried deformed fetuses over a 6-year period (Hines 1975). Although 19 percent of 64 pregnant black-tailed

deer from Camp Pendleton, San Diego Co., California carried abnormal fetuses, none of the deformities included cleft palate (Bischoff 1958).

The causes of this case of cleft palate remain unclear, and the following discussion is of necessity speculative. Tule elk at Point Reyes have been affected by paratuberculosis (Jessup et al. 1981) and copper deficiency (Chapter V), as well as a prior population bottleneck (McCullough 1969). The teratogenic effects of certain range plants must also be considered (Keeler 1978).

No suggestion that paratuberculosis produces congenital birth defects could be found in published literature. Inbreeding in populations of a species that normally outcross may lead to a reduction of viability of young (Templeton and Read 1983). Arthrogryposis and cleft palate are inherited as autosomal recessive traits in some breeds of cattle (Shupe et al. 1967a, Greene et al. 1973, Leipold 1978). Presumably, cleft palate in the tule elk calf could also be the result of a recessive trait. All tule elk are descendent from a remnant population of approximately twelve individuals in 1873 (McCullough 1969). The affected calf's dam and the two largest male elk at Point Reyes during the 1980 rut were descended from a small tule elk

herd at San Luis Island National Wildlife Refuge, Merced Co. The affected calf was likely sired by one of these two males. Consequently, it may be even more inbred.

Copper deficiency in domestic stock has resulted in congenital ataxia and gross cavitation of the cerebral hemispheres in severe cases (Kavanagh et al. 1972). Complicated copper deficiency can cause incomplete calcification of cartilaginous plates (Allcroft and Parker 1949). Neither of these lesions was evident in the tule elk fetus. Copper deficiency in tule elk at Point Reyes was most pronounced in the summer of 1979 and winter 1981, the latter being the gestation period associated with this abnormality.

The maternal ingestion of certain range plants containing alkaloid teratogens produces a syndrome known as "crooked calf disease" in domestic stock (Keeler et al. 1977, Keeler 1978). Normally, less than 10 percent of the stock in a herd are affected (Shupe et al. 1967b). The syndrome is characterized by arthrogryposis, scoliosis, torticollis, and cleft palate. Cleft palate may occur with other abnormalities, but occasionally it is the only detectable deformity (Shupe et al. 1967b). The disease is the result of pregnant animals ingesting plants containing

teratogenic alkaloids between the 40th and 70th days of pregnancy. One genus noted for its teratogenic alkaloids is Lupinus (Keeler et al. 1977, Keeler 1978). The gestation period in tule elk is approximately 250 days with the rut in August and September and most calving in May or early June. Thus, the period of insult in tule elk would be in October and November. Dietary records for September 1980 through May 1981 (Chapter XIV) show that Lupinus spp. (mainly L. arboreus) constituted between two and 31 percent of the diet in bimonthly samples between early September and late November 1980 and less than one percent in bimonthly samples between early December 1980, and May 1981. Thus, the diet of tule elk included a plant species with the potential to contain high levels of teratogenic alkaloids during a critical period of fetal development.

CONCLUSIONS

The causes of the cleft palate in this calf remain speculative. Closer inspection of fetuses from cervid species with varying levels of inbreeding and use of teratogenic plants may provide insight into the frequency and cause of this deformity.

CHAPTER VIII

ANTLER ANOMALIES IN TULE ELK

The two mature male and eight mature female tule elk reintroduced to Point Reyes National Seashore in July 1978 showed severe nutritional stress related to copper deficiency by May 1979 (Chapter V). One of the two males died, possibly of peritonitis associated with osteophagia (R. Fisher, pers. comm.). The second was so severely emaciated that it was transferred to Grizzly Island State Wildlife Management Area, Solano Co., for nutritional therapy (Chapter V). Antler abnormalities were evident in both of the mature males and in four yearling males born at Point Reyes in 1978.

METHODS

The skull of the mature male dying at Point Reyes was preserved in the natural history collection at Point Reyes National Seashore (PORE 312) as was that of a yearling male dying at Point Reyes in 1979 (PORE 319). The left antlers of the surviving mature male grown in the spring 1979 and 1980 cast in March 1980 and 1981, respectively, were also preserved (PORE 481, 482). This male's antlered skull cap was mounted after its death in 1981 and is presently in the

Department of Fish and Game administrative building at Grizzly Island. The antlered skull (PORE 480) of a male tule elk born at Point Reyes in May 1981, and destroyed in January 1985, was used as a control.

All antlers were radiographed at a private veterinary laboratory (West Marin Veterinary Clinic). Select radiographs were examined by Dr. A. B. Bubenik.

RESULTS

Both mature males exhibited a similar pattern of antler anomaly. Antlers of the male dying in 1979 appear normal in development of the proximal portion of main beam and brow and bez tines, but are then bilaterally malformed with an anterior shift of the beam ending in a vertically oriented club (Fig. 26). This elk died in July, prior to the normal shedding of velvet. The more massive, cast, 1979-1980 antler (PORE 481) of the surviving male transferred to Grizzly Island exhibits a similar pattern with a sharp downward bend in the main beam beyond the bez tine and the distal portion of beam palmate with four small tines protruding from it (Fig. 27). The 1980-1981 antlers are normal in appearance (Fig. 27). Antlers for 1981-1982 are considerably smaller than the previous year's, but

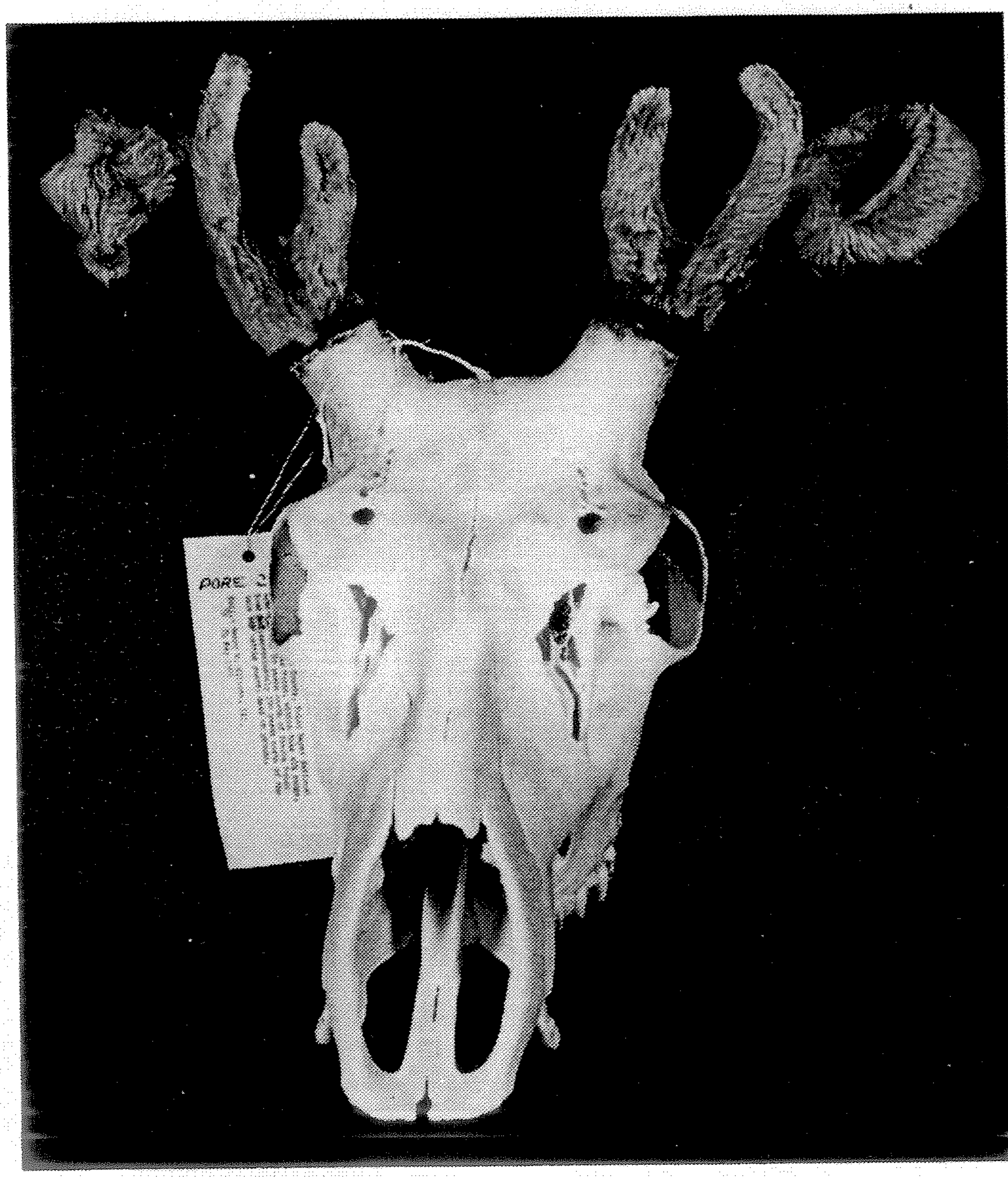

Figure 26. Photograph of skull of adult male tule elk showing bilateral deformed antlers. Photo by Jerald Morse.

Figure 27. Photograph of left antlers of adult male tule elk showing deformed antler in 1979 (upper), normal antler in 1980 (center) and smaller but normal antler for 1981 (lower). Antlers were bilateral in all years. Photo by Jerald Morse.

otherwise normal for an old male (Fig. 27). Spike antlers of the yearling male dying at Point Reyes in 1979 exhibit a bilateral corkscrew anomaly (Fig. 28).

A radiograph of the cast antler formed by a mature male at Point Reyes in 1979 (PORE 481) shows a poorly developed cortex in comparison to the antler grown by the same male at Grizzly Island the following year (PORE 482) and the control from Point Reyes in 1985 (PORE 480) (A. B. Bubenik, pers. comm.).

DISCUSSION

Antler anomalies of the type recorded here have been noted previously in *C. elaphus* (Bubenik 1966). The bilateral nature of these deformities suggests they were not caused by physical injury, and the fact the deformity is not evident in consecutive years suggests nongenetic cause (Goss 1983). Anomalies of the type reported here have been associated with retarded mineralization (Bubenik 1982). Rotation and bending down of the beam in the two mature males in 1979 suggests the beams bent under their own weight and were subsequently mineralized in that position (Bubenik 1982). The yearling males' corkscrew antlers also suggest deep osteomalacy (Bubenik 1966).

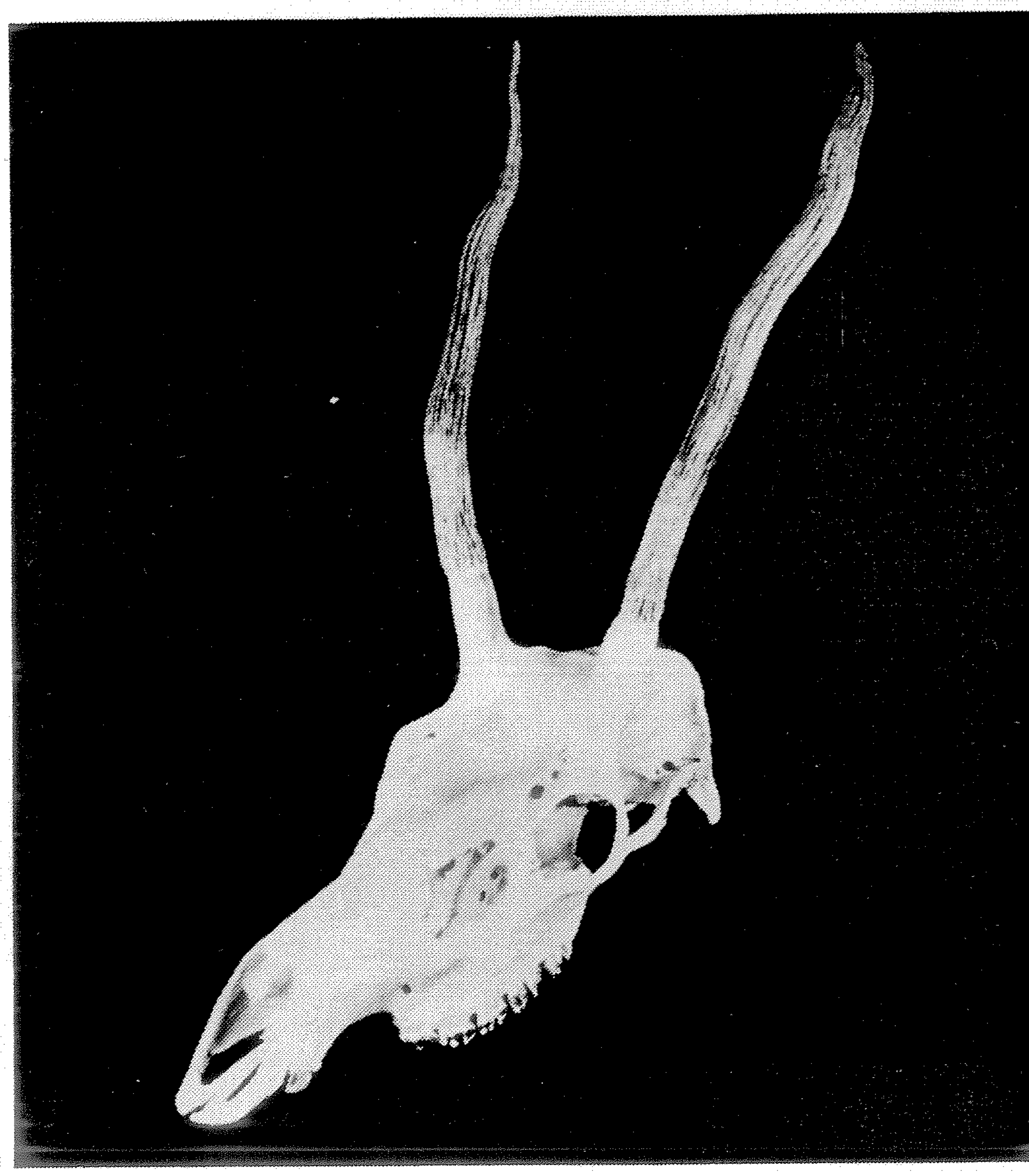

Figure 28. Photograph of skull of yearling male tule elk showing bilateral corkscrew antlers. Photo by Jerald Morse.

Previous studies have shown such anomalies to be associated with calcium and phosphorus imbalances (Bubenik 1966) and protein deficiency (French et al. 1956). Normal appearing but brittle antlers in tule elk in the Owens Valley have been attributed to calcium deficiency (McCullough 1969). Huber (1938) suggested an association between antler anomalies of this type and lung worm infestations. Mechanisms for any such relationship remains obscure. Hair calcium and phosphorus levels were comparable in tule elk at Point Reyes and other locations in California (Gogan, unpubl. data). However, investigations of copper levels in tule elk at Point Reyes from 1978-1981 show the herd suffered from copper deficiency in 1979 and 1981 (Chapter V). Only normally developed antlers have been recorded from 1980 through 1985. Serum copper levels in the male transferred to Grizzly Island were equal in July 1979 and July 1980, following dietary supplementation (Chapter V). The diminutive but normally shaped antlers of 1981-1982 (Fig. 2) are not thought to reflect trace element deficiency, but rather the extreme age of this animal (10+ years when introduced to Point Reyes in 1978).

Osteomalacy associated with copper deficiency has been recorded in both domestic and wild ungulates. Bone

disorders associated with copper deficiency in cattle include osteoporosis, spontaneous bone fracture, and delayed and incomplete calcification of cartilaginous plates (Irwin et al. 1974, Owen 1981). Copper deficiency in wild cervids has been reported as ataxia in adult red deer (C. e. elaphus) (Barlow et al. 1964, Terlecki et al. 1964), osteoporosis in adult reindeer (Rangifer tarandus) (Hyvarinen et al,. 1977), and irregular hoof keratinization and reduced reproductive rates in adult moose (Alces alces) (Flynn et al. 1977). It would seem, therefore, that copper deficiency has the potential to cause antler deformities of the type reported here.

However, the radiographs are not consistent with the possibility of delayed mineralization attributable to trace element deficiency (A. B. Bubenik, pers. comm.). Delayed mineralization of the type evident is characteristic of inadequate testosterone levels (A. B. Bubenik, pers. comm.). Yet, antlers grown under low testosterone levels do not shed their velvet (Bubenik 1982). All 6+ month male elk at Point Reyes surviving to the fall have shed the velvet from their antlers. Thus, the deformities are not consistent with inadequate mineralization due to low testosterone levels.

The nature of the antler deformities suggests inadequate mineralization not attributable directly to either low levels of copper or testosterone. This suggests a low general nutritional level in tule elk at Point Reyes in 1979, rather than low levels of a single element of hormone.

CONCLUSIONS

The deformed antler growth observed in tule elk at Point Reyes in 1979 is attributable to inadequate mineralization. Neither copper deficiency nor possible low testosterone levels provide adequate explanations for the nature of deformity observed. This suggests a rather general nutritional inadequacy resulting in malformed antlers.

CHAPTER IX

TULE ELK SOCIAL ORGANIZATION AND HOME RANGE

Social organization in North American elk has been recorded as variable in response to different environmental conditions, traditional associations, and human disturbances. Social organization may play a critical role in determining the outcome of reintroductions of elk. A model of elk social organization for sedentary elk proposes that long-term group cohesiveness is favored by stable habitat and forage (Franklin and Lieb 1979). The social organization of tule elk recently reintroduced to Point Reyes is compared to this model and other accounts of elk social structure. A measure of home range size is made for tule elk at Point Reyes.

METHODS

Individual elk at Point Reyes usually were located at least twice each week and frequently daily between July 1979 and September 1981. Monthly observations were made from October 1981 through August 1984. Group size and composition was recorded by sex and age class. Combinations of ear tags permitted identification to age class and in many cases to individual.

The location of elk groups was recorded to the nearest 200 x 200 m cell representing a subdivision of the Universal Transverse Mercator (UTM) grid system. To avoid bias, only sightings recorded while observers were away from the road or hiking trails were used in calculating home range. Home range size was determined by the harmonic mean measure (Dixon and Chapman 1980) for two social units, the cow-calf herd and cows with neonatal calves.

RESULTS

Herd size of the tule elk on Tomales Point ranged between 13 and 17 from July 1979 through September 1981 and increased to 41 by August 1984 (Chapter IX).

Male-Female Association

The herd contained only males less than 2 years old from July 1979 through May 1980. The adult cows and 1978 and 1979 cohorts remained together as a single unit from July 1979 through March 1980, with the exception of a yearling female and a yearling male which were each solitary for approximately a week before dying. The 1979 rut was virtually nonexistent; the three yearling males exhibited little agonistic behavior, and none was driven

away from the cow-calf group. Yearling males left the cow-calf group in March 1980, but rejoined them within a week. They shed their spike antlers in March after rejoining the cow-calf herd.

In May 1980, two emaciated 2-year-olds (one male, one female) suffering from paratuberculosis began a long period of intermittent association with the cow-calf group which continued until the male died and the female was destroyed (Chapter VI). The two healthy, 1978 cohort males (2-year-olds) were frequently sighted away from the cow-calf group between mid-May and mid-September 1980 in various combinations, including solitary, in association with each other and in association with the emaciated male and female suffering from paratuberculosis. Both healthy males rejoined the females briefly in mid-June and mid-August attempting to herd them on both occasions. These bulls were sighted away from the cow-calf herd until a single 2-year-old male was seen with the females on September 20. By September 27, the second 2-year-old male had displaced the first from the cow-calf herd. Both males were with the cow-calf herd from mid-October until the end of that month. The rut was judged ended when both 2-year-old males were sighted in company and away from the cow-calf herd on October 31. At no time was the single

yearling male displaced from the cow-calf herd.

The 2-year-old males remained away from the cow-calf herd through the end of 1980, but were seen with it on January 2, 1981. All elk remained together as a single unit through March 2. The two 2-year-old males were alternately sighted away from and with the cow-calf herd throughout March, during which time antlers were shed. They then maintained a continuous association with the cow-calf herd through April.

The single 2-year-old male (1979 cohort) was herding a portion of the cow-calf herd in mid-June 1981. By late July, a 3-year-old male had displaced the younger male and a spike bull which had also been in association with the females. One of the two 3-year-old males was with the cow-calf herd from July 20 through October 4, although the individuals exchanged places several times. From 1982 through 1984, only a single mature male was in association with the cow-calf herd, and yearling males were absent during the rut.

Female-Female Association

Female-female associations for 1979 to 1981 are

summarized following the pattern of social organization proposed by Franklin and Lieb (1979) (Table 29). Subgroups of female elk were uncommon at all times except the 1981 calving period. The only observation of a cow separating from the group during the winter-spring period was of one adult female away from the cow-calf group on two consecutive days in January 1981 (Table 29). It is possible she aborted at that time. Other sightings of subgroups of cow elk occurred only during the calving season (May-June). The mean of 47 percent of sightings being of subgroups during spring 1980-1981 calving is somewhat misleading (Table 29). Only one adult female left the cow-calf herd in 1980, and only 8 of 43 observations (18%) were of subgroups. In 1981, seven of nine 2+-year-old females became solitary in the calving period, and the cow-calf group ceased to exist: 24 of 25 observations (96%) were of subgroups. There was a pattern of individual pregnant females leaving the cow-calf herd prior to parturition and then forming groups of two or three post parturient females. A primiparous 2-year-old female left the cow-calf herd on April 27 and was seen with a new calf on May 1. Two adult females were sighted in company on May 6. The recently calved 2-year-old female was with three adult females on May 8. A primiparous 3-year-old gave birth to a stillborn calf approximately 2

Table 29. Cohesiveness of the cow-calf group of tule elk on Tomales Point from July 1979 through September 1981.

Period	Duration in Months	Number of Days Cow-Calf Group Counted	Days Subgroups Observed[a] Number	Days Subgroups Observed[a] Percent
Winter-spring (November-April)	6	108	2	2
Spring calving (May-June)	2	68	32	47
Summer-fall rutting (July-October)	4	46	0	0

[a]Excluding sick animals.

weeks premature on May 8 (Chapter VII). An adult cow was located with a less than 12-hour-old calf on May 12. Two adult cows and a second primiparous 2-year-old female were each sighted with young calves, but otherwise alone, between May 15 and May 23. Three pairs of cows with calf associations developed: two pairs of an adult female with a 2-year-old female and one pair of adult females. The cow-calf group remained intact as a social unit during the summer-fall rutting period of 1979 through 1981 (Table 1).

Observations from the fall of 1981 through 1984 show the increasingly large cow-calf herd has remained together as a cohesive social unit at all times except the calving period. In no year has the cow-calf herd been split by rutting males.

Home Range

The home range (90% isoline) (Dixon and Chapman 1980) for the cow-calf group from July 1979 through September 1981 was calculated as 359 ha. It was centered in the southern portion of the elk range (Fig. 29). Cows with newborn calves ranged over a slightly larger (420 ha) but virtually identical area during the 1981 calving season (Fig. 30).

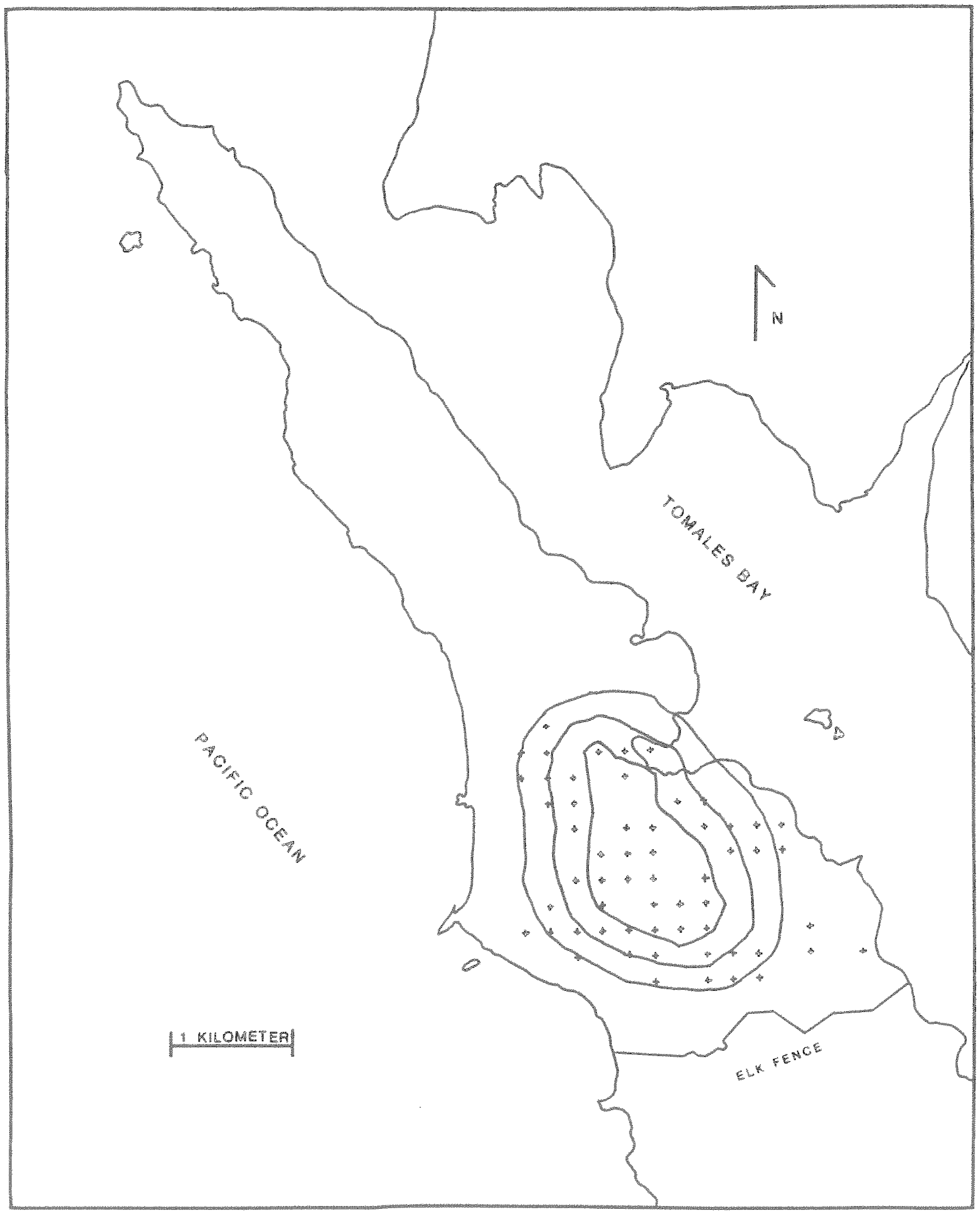

Figure 29. Activity loci and three isolines for the cow-calf elk herd from 1979 through 1981. Isolines enclose 90, 60 and 30 percent of loci (N = 102).

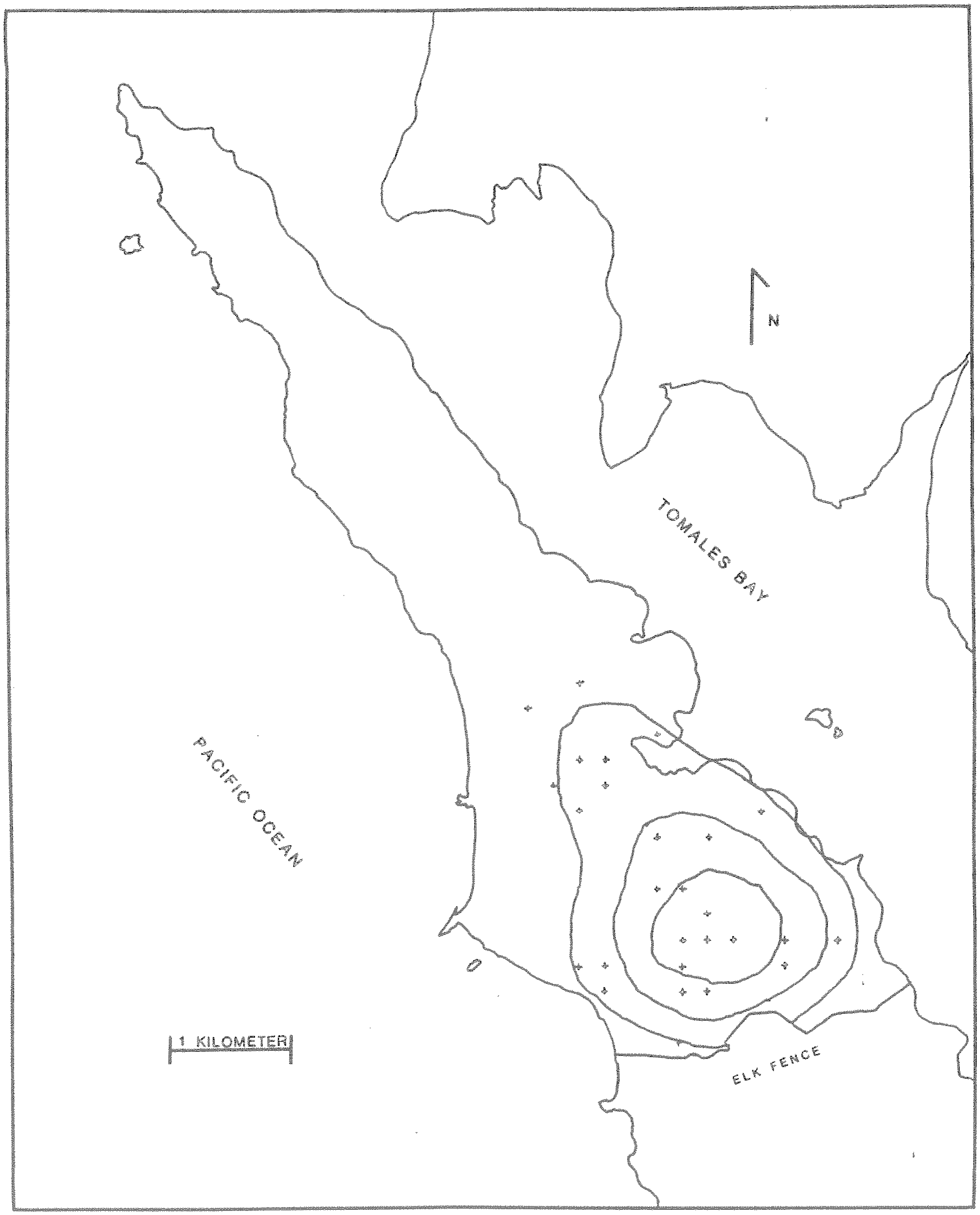

Figure 30. Activity loci and three isolines for cow elk with newborn calves during May and June 1981. Isolines enclose 90, 60 and 30 percent of loci (N = 34.

DISCUSSION

The tule elk reintroduced to Point Reyes exhibited a strong social cohesiveness from the time of their release (Ray 1981) which continued through 1984. Factors contributing to this social bonding are: 1) all elk were part of a herd of less than 30 animals at San Luis Island National Wildlife Refuge, Merced Co., at the time of relocation to Point Reyes; and 2) the relocated elk were restricted to a small holding pen for 6 months prior to being released on Tomales Point. Strong social bonding was also exhibited by tule elk at Grizzly Island State Wildlife Management Area, Solano Co., since their introduction in 1977 (H. Sohrweide, pers. comm.). Elk relocated to Grizzly Island came from a herd of less than 50 at the Tule Elk Reserve, Kern Co. and were restricted to a small holding pen for 3 months prior to release.

Other relocated groups of tule elk have shown little or no social cohesiveness when released (Bureau of Land Management 1980, 1981). In some instances, individual and small groups of elk have scattered widely (Willison and Hanson 1983), while in other instances released groups have fragmented into discrete subunits even after being

restricted to a holding pen on the release site for 4 weeks (Phillips 1985).

Male-female associations observed in this study closely match those reported in other studies of North American elk (McCullough 1969, Franklin et al. 1975, Bowyer 1981) and agree with the model proposed by Franklin and Lieb (1979). Failure of yearling males to separate from the cow-calf group during the rut of 1979 may be attributed to the complete absence of older bulls. Older males tolerated a yearling male's presence with the cow-calf herd in 1980, but in subsequent years yearling males have not been sighted with the cow-calf group when the group was accompanied by a rutting bull. In contrast, yearling males regularly associated with the cow-calf herd throughout the rut at Grizzly Island (H. Sohrweide, pers. comm.).

Female-female associations fit the proposed model in two of the three periods of the annual cycle (Table 29). The winter-spring period of stability is somewhat longer for tule elk at Point Reyes than reported for Roosevelt elk at Prairie Creek (Franklin and Lieb 1979). There, cow elk leaving their traditional cow-calf herd have been seen associating with other groups of females (Franklin et al. 1975). The absence of other cow-calf groups at Point Reyes

may have reduced the likelihood of females leaving the group.

A distinct difference in social structure of cow-calf groups of tule elk at Point Reyes and the model proposed by Franklin and Lieb (1979) was evident during the summer-fall rutting period. The cow-calf group at Point Reyes did not divide into subgroups in any year, even though it increased to more than 30 animals. In contrast, Roosevelt elk at Prairie Creek were observed in subgroups during the rut more than 75 percent of the time (Franklin and Lieb 1979:188). Failure of cow-calf groups to divide into subgroups is not unique to Point Reyes. The cow-calf group at Grizzly Island formed two subgroups only in the 1980 rut, while still relatively small. It has remained intact, with several mature and yearling males in consort, in all other years (H. Sohrweide, pers. comm.). Similarly, Roosevelt elk introduced to Afognak Island, Alaska remained in aggregations in excess of 100 animals during the rut (Troyer 1960). Possible reasons for such variation in herd size are unclear. While all three populations are the result of relocations, Troyer's (1960) observations were made 30 years after the translocation.

The existence of strong social cohesiveness in cow-calf

tule elk at Point Reyes is consistent with observations in other studies (Franklin et al. 1975, Franklin and Lieb 1979, McCullough 1969, Jenkins and Starkey 1982). However, other workers have concluded the only consistent social unit in the populations under study is the cow-calf unit (Martinka 1969, Knight 1970, Shoesmith 1979), with frequent interchange between larger cow-calf herds. Franklin and Lieb (1979) attribute differences in patterns of social organization to differences in environmental stability, with more cohesive cow-calf herds developing under stable environmental conditions. However, Houston (1982) noted severe depredation of elk populations may affect the ability to establish stable cow-calf units. In general, long-term cow-calf social units have been recognized in unhunted or lightly hunted elk populations (Graf 1954, McCullough 1969, Franklin et al. 1975, Franklin and Lieb 1979, Jenkins and Starkey 1982), while little social attachment beyond the cow-calf unit has been noted in populations subjected to heavy hunting or live-trapping of both sexes (Martinka 1969, Knight 1970, Shoesmith 1979).

A home range of the cow-calf herd at Point Reyes from summer 1979 through fall 1981 of 360 ha agrees closely with the home range estimate of 390 ha for the three months following release (Ray 1981). A cow-calf herd of 10 to 12

tule elk reintroduced to the Diablo Range, Contra Costa Co. showed a reduction in home range size from 2400 ha to 505 ha in 3 years (Phillips 1985). Possibly, the long period of confinement in a holding pen and barbed wire livestock cross fences impeded movement of tule elk at Point Reyes when first released (Ray 1981). Dietary supplements provided at the site of the original holding pen from mid-Septeber 1979 through April 1980 may have discouraged movement. Observations of tule elk at Point Reyes between fall 1981 and fall 1984 indicate the area of Tomales Point utilized has increased with increasing population size. However, the area utilized through 1981 may be adequate for elk. Home range of a cow-calf herd of Roosevelt elk in Prairie Creek Redwoods State Park was recorded at 300 ha for a herd of 27 (Franklin et al. 1975) and 400 ha for a herd size of 39 (Bowyer 1981). The home range of individual Rocky Mountain elk in Wichita Mountains National Wildlife Refuge, Oklahoma was 313 ha (Waldrip and Shaw 1979).

In contrast, home ranges of cow-calf herds with a mean group size of 27 of Roosevelt elk in the Hoh River Valley of Olympic National Park exceed 1,000 ha (Jenkins and Starkey 1982). Home ranges for cow-calf groups consisting of an individual female Rocky Mountain elk and her calf in

the central Rockies range from 930 ha (Martinka 1969) to 3,056 ha (Craighead et al. 1973). These large home ranges may be the result of dispersed forage resources (Jenkins and Starkey 1982). Also, all represent studies of resident portions of otherwise migratory elk populations. The response of resident elk to seasonal utilization of portions of the home range by migratory elk may contribute to larger home range size.

CONCLUSIONS

Tule elk translocated to Point Reyes National Seashore showed strong cohesiveness matching a generalized model of elk social organization. Possible reasons for the cohesiveness include: 1) prior social bonding at the capture site; 2) confinement in a holding pen at the release site; and 3) absence of other elk herds in the vicinity to act as an attraction. Home range size in elk at Point Reyes from 1978 through Fall 1981 was between 360 and 420 ha.

CHAPTER X

DENSITY AND POPULATION COMPOSITION OF BLACK-TAILED DEER BY DIRECT OBSERVATION

Black-tailed deer and livestock coexisted on Tomales Point for approximately 100 years and presumably came into equilibrium with one another and range resources. Elimination of livestock grazing marks a major disruption in this equilibrium. The suitability of line transects for determining deer density and population composition was assessed as a possible means for monitoring long-term changes in the deer population.

METHODS

Numbers By Direct Observation

A series of east-west transect lines totalling 15.9 km were systematically plotted 600 m apart on a USGS 7.5 minute quadrangle map of Tomales Point (Fig. 31). Inspection of each line in the field showed passage was frequently blocked by dense stands of scrub. Traversable portions of each transect line were walked within three hours of dawn in May 1980. Either one or two observers sampled each line. Observers scanned the terrain before

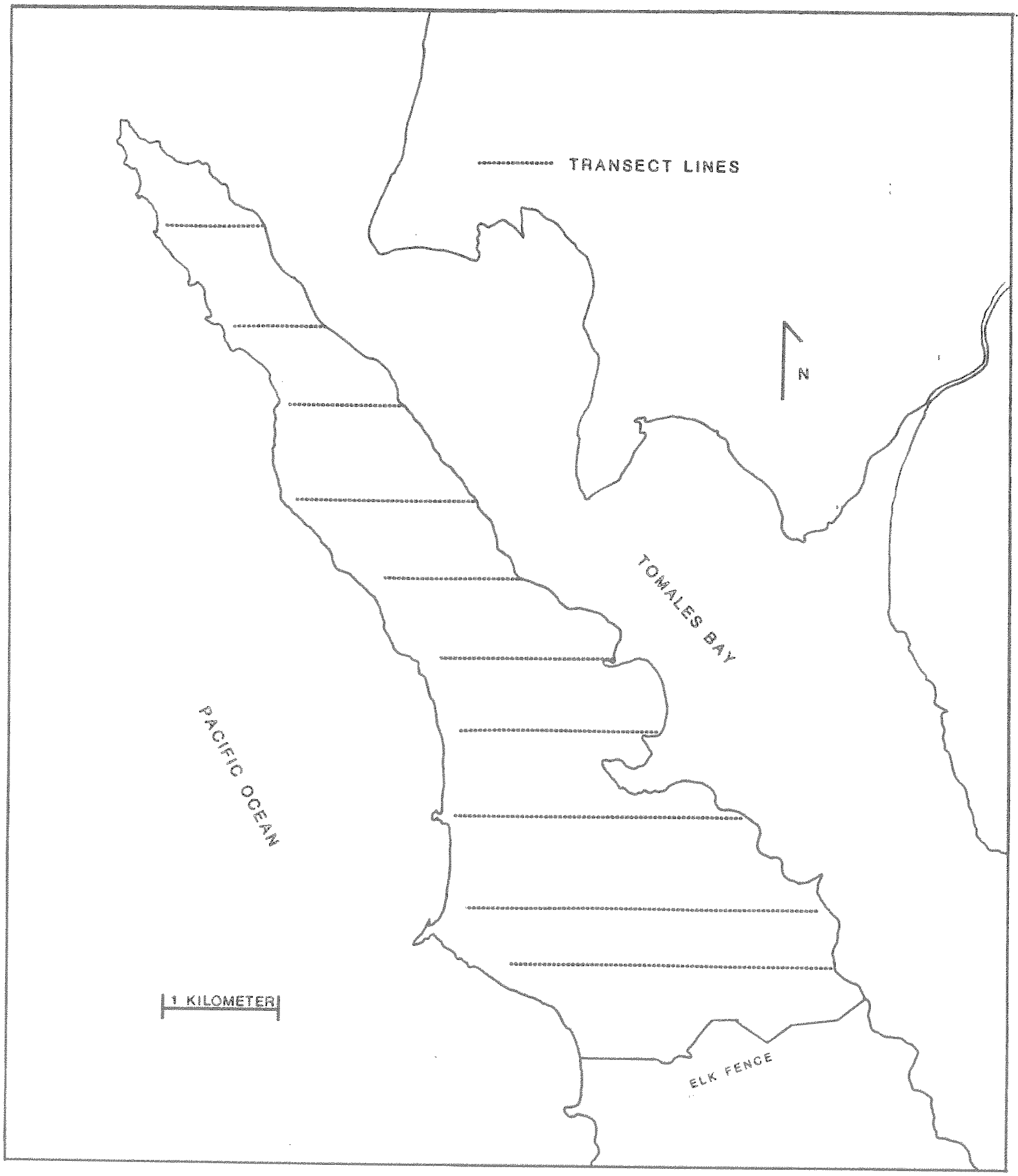

Figure 31. Location of transect lines for censuses of black-tailed deer on Tomales Point.

them, to their sides, and behind them for deer, frequently with binoculars. Upon sighting a group of deer, observers recorded the sighting distance to the middle of the group (measured with an optical range finder), sighting angle (measured with a compass), and group size. A total of 21 deer groups were sighted over 8.7 km of transect line.

The length of transect line required for a density estimate with a coefficient of variation of 20 percent or less was calculated by the following formula (Burnham et al. 1980:36):

$$L_2 = \frac{b}{(cv_2(D)^2} \left(\frac{L_1}{n_1}\right) \qquad (8)$$

where L_2 is the length of transect line required to obtain a desired coefficient of variation ($cv_2(D)$), n_1 is the number of animal groups sighted in a pilot census of length L_1, and b is calculated from the formula:

$$b = n_1(cv_1(D))^2, \qquad (9)$$

where n_1 is as above and $cv_1(D)$ is the coefficient of variation of the pilot survey. A value of b = 3 is recommended as slightly overestimating the sample required (Burnham et al. 1980:35).

Setting the desired coefficient of variation at 20 percent and solving equation (1) with the results of the pilot survey yields:

$$L_2 = \frac{3}{(0.2)^2}\left(\frac{8.7}{21}\right) = 31.0 \text{ km} \qquad (10)$$

In practice, this requires sampling along the entire 15.9 km system of transect lines twice (replication) to obtain a density estimate with the desired coefficient of variation. To sample the entire system of mapped transects, passages were cut through all impassable stands of scrub. The precision of replicating samples was increased by permanently marking all transects at 100-m intervals with 2-m sections of rebar.

The entire transect system was walked within 3 hours of dawn in nine separate sample months between November 1980 and September 1981. The 15.9 km of line was sampled in 13 segments. Only a single segment was walked each day to reduce the possibility of the observer disturbing deer on adjacent lines or while moving to the starting point of a transect line. Data were recorded as in the pilot survey. All observations were truncated at a perpendicular distance of 300 m to avoid the possibility of overlap between adjacent lines.

Burnham et al. (1980) demonstrated that the probability of detecting an object is a function of its perpendicular distance from the transect line. A general formula for all estimates of density is given by Ratti et al. (1983:1089) as:

$$D = \frac{n\ f(0)}{2L}, \qquad (11)$$

where n is the number of groups sighted, L is the length of line sampled, and f(0) is an expression of the probability of detecting a group of deer. "The quantity f(0) is estimated by fitting an appropriate model (curve) to the perpendicular distances (x_i) to represent their probability density function f(x) and evaluate this function at its origin f(0)." (Ratti et al. 1983:1090).

Estimates of the density of deer groups were calculated from the Fourier series, exponential polynomial and exponential power series estimators of program TRANSECT (Burnham et al. 1980). The Fourier series is recommended as a general estimator as it is nonparametric as well as being "<u>model robust</u>, <u>pooling robust</u>, and has the <u>shape criterion</u> and high estimator efficiency" (Burnham et al. 1980:133). However, the Fourier series seriously underestimates density if animals move away from the

observer prior to detection. The exponential power series and exponential polynomial estimators are more robust than the Fourier series to this possibility. The extent to which deer move away from observers before being sighted cannot be measured. Thus, the only means to test for this possibility is to examine results of the three estimators by comparing each probability detection function to the original data with a chi-squared test (Burnham et al. 1980, Holt and Powers 1982). A sample size of at least 40 observations is recommended (Burnham et al. 1980).

The density of individuals was calculated by multiplying each estimate of group density by mean group size. A standard error for this estimate is derived from the coefficient of variation of both estimates (Burnham et al. 1981:475). Total numbers were obtained by multiplying the density estimate by the area of Tomales Point. Data were analyzed separately for each sampling period. Then, all samples were combined to produce weighted average and pooled estimates of density and associated variances (Burnham et al. 1980, 1981).

The standard error around the estimate of group size is often greater than the standard error of the estimate of group density. A possible means of reducing the estimate

of group size standard error is to pool all records of group size taken during each census with all records of group size made incidental to other aspects of field work. However, comparisons of both data sets (Table 30) show the mean size of groups seen on transects tends to be smaller than groups sighted in the course of other field work. This suggests small groups of deer were less likely to be detected while conducting other work. Also, observers frequently followed rather regular routes when not sampling transect lines. Records undoubtedly include repeated sightings of a single group of deer within each sampling period. Consequently, no pooling of observations was done.

Inspection of monthly mean group size (Table 30) shows up to a 2.5-fold difference between months. Such differences reflect the species' social organization and seasonal peak in fawning. These differences are likely to affect the number of groups of deer available for detection, and consequently, estimates of group density. An overall and pairwise comparison of monthly group size was made with the Kruskall-Wallis test, and results expressed in a manner similar to the Duncan test (Figure 32). Replicate monthly samples with non-significant differences in mean group size ($P < 0.10$) were combined into four sets and, a fifth set was created by combining

Table 30. Mean group size of black-tailed deer by month for incidental observations and observations on transect lines.

Sample Period	Incidental Observations				Line Transect Observations			
	N	$\bar{x}$	SE	Range	N	$\bar{x}$	SE	Range
Nov. 1980	28	2.42	0.32	1-8	61	2.47	0.21	1-8
Dec. 1980	26	3.26	0.40	1-9	22	4.08	1.43	1-36
Jan. 1981	16	3.87	0.75	1-10	19	3.85	0.64	1-10
Feb. 1981	20	3.60	0.50	1-8	24	3.00	0.54	1-14
Apr. 1981	25	2.40	0.26	1-6	24	1.53	0.17	1-4
May 1981	60	2.36	0.19	1-7	45	1.88	0.14	1-5
Jul. 1981	46	2.58	0.27	1-11	21	1.80	0.22	1-5
Aug. 1981	140	3.01	0.22	1-14	35	2.17	0.22	1-6
Sep. 1981	56	2.55	0.23	1-10	56	2.17	0.16	1-6

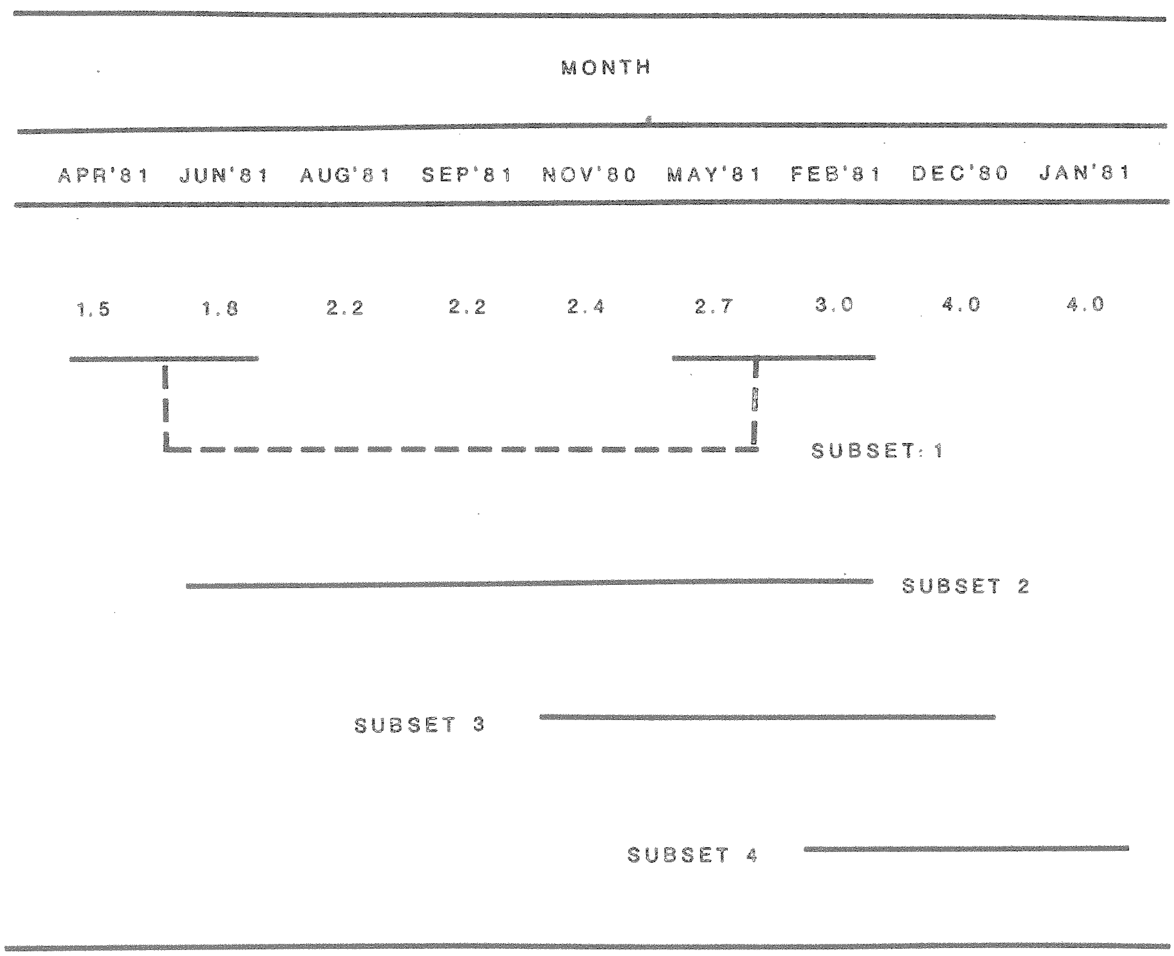

Figure 32. Results of Kruskall-Wallis tests for significant differences ($P \leq 0.10$) in group size of black-tailed deer between sample periods. Means connected by common lines are non-significant.

all censuses in which the number of groups observed exceeded the recommended number of 40 observations. Weighted average and pooled estimates of density and variance were calculated for each set of samples.

Population Composition

Composition of groups sighted from transects were recorded in November 1980 and from April through September 1981. Animals were not classified from December through March as this is the period of antler loss for males and it is difficult to distinguish males from females (Dasmann and Taber 1956, Taber and Dasmann 1958). Individuals were classified as adult male or female, yearling male or female, and unsexed fawn or unknown, following established criteria (Dasmann and Taber 1956, Taber and Dasmann 1958). Groups containing individuals classified as unknown were dropped from analysis.

RESULTS

Numbers By Direct Observation

The number of deer groups sighted reached the recommended 40 in three of the nine sampling periods

(Table 31). In most instances the perpendicular detection function f(0) of the Fourier series estimator provided the best fit to the data as indicated by the chi-squared goodness of fit test (Table 32). In addition, the number of Fourier coefficients computed to estimate f(0) is not more than two for any sample (Table 31). Estimates of density requiring more than three Fourier coefficients "reflect anomalies in the data" (Burnham et al. 1981:473). The calculated length of transect line necessary to produce a sample of adequate size to generate an estimate of density with a coefficient of variation of 20 percent or less was not tested directly owing to variation in group size discussed below. However, any combination of two sequential samples, i.e., 31.8 km of transect line, produce the minimum sample of 40 observations recommended. The minimum sample was achieved in a single month in three cases.

As the Fourier series estimator fits the preponderance of data sets and is considered a robust estimator (Burnham et al. 1980, 1981), density estimates generated by the Fourier series estimator are presented for all months (Table 31). There is a four-fold difference in group density estimates between months, with lower density estimates associated with smaller sample sizes.

Table 31. Results of line transect censuses of black-tailed deer on Tomales Point, as derived from the Fourier Series estimator.

Sample	N	Group Size		No. of Terms in Fourier	f(0)		Number of Deer Groups per Hectare		Number of Deer per hectare		Total Population Size		Adult Population Size	
		$\bar{x}$	SE	Series	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Nov. '80	61	2.48	0.21	1	0.006	0.06×10^{-2}	0.117	0.018	0.29	0.06	298	62	197	41.0
Dec. '80	22	4.08	1.43	1	0.007	0.06×10^{-2}	0.047	0.011	0.19	0.08	198	82	-	-
Jan. '81	19	3.85	0.64	1	0.005	0.10×10^{-2}	0.029	0.009	0.11	0.04	115	41	-	-
Feb. '81	26	3.00	0.54	2	0.009	0.13×10^{-2}	0.715	0.018	0.21	0.07	219	72	-	-
Apr. '81	24	1.54	0.17	1	0.008	0.07×10^{-2}	0.046	0.011	0.07	0.02	72	21	37	1.4
May '81	45	1.68	0.14	1	0.006	0.06×10^{-2}	0.078	0.015	0.15	0.03	160	31	108	22.3
Jul. '81	21	1.81	0.22	1	0.006	0.09×10^{-2}	0.037	0.010	0.07	0.20	69	205	51	151.7
Aug. '81	35	2.10	0.22	2	0.007	0.13×10^{-2}	0.081	0.020	0.19	0.05	196	52	142	40.0
Sep. '81	56	2.18	0.17	1	0.005	0.08×10^{-2}	0.095	0.016	0.21	0.04	212	41	168	32.4
Weighted Averaged	307	2.42	0.13	-	-	-	0.067	0.010	0.16	0.03	166	31	-	-
Pooled	307	2.42	0.13	1	0.008	0.02×10^{-2}	0.064	0.010	0.15	0.03	158	31	-	-

Table 32. Chi-squared goodness of fit test of the perpendicular detection function of the Fourier Series (FSER), exponential polynomial (EXPL) and exponential power series (EXPS) to observations of black-tailed deer by sample period.

Sample Period	N	Estimator					
		FSER		EXPL		EXPS	
		X^2	Prb > X^2	X^2	Prb > X^2	X^2	Prb > X^2
Nov. 1980	61	1.077	0.783	2.844	0.584	2.916	0.572
Dec. 1980	22	1.077	0.783	5.203	0.635	5.173	0.638
Jan. 1981	19	1.200	0.549	2.547	0.293	2.419	0.298
Feb. 1981	24	1.561	0.668	-	-	3.148	0.207
Apr. 1981	24	1.473	0.688	6.040	0.109	0.489	0.783
May 1981	45	0.408	0.815	0.174	0.676	0.190	0.663
Jul. 1981	21	0.015	0.992	1.620	0.203	-	-
Aug. 1981	35	2.376	0.795	1.619	0.899	1.707	0.888
Sep. 1981	56	2.943	0.890	0.424	0.515	2.870	0.825

No comparable pattern is apparent for monthly differences in group size. For example, numbers of groups sighted varied by a factor of two between April and May, although mean group size is similar. Estimates of density by month show no relationship to the number of groups sighted. Burnham et al. (1981:479) have noted "the number of birds seen on a line transect is a poor index to density."

Monthly estimates of population size ranged form a high of 298 in November 1980 to a low of 69 in July 1981 (Table 31). The lower limit of the standard error extended below the actual number of deer sighted on the study area in July 1981. In this case, the lower limit of the standard error has been truncated at the number of individuals observed. Weighted average and pooled estimates of density derived from all monthly samples produced similar estimates of density (Table 31). The estimates would be identical if the number of terms used in the Fourier series estimator was identical for all samples (Burnham et al. 1981). However, both point estimates approximate the number of deer actually sighted in the study area in November 1980 and September 1981.

The pooled and weighted average estimates of density derived from subsets of censuses with non-significant

differences in group size produced density estimates similar to the pooled and weighted average estimates for all samples (Table 33). The subset of censuses with more than 40 observations in each animal group provided the highest density estimate. However, the point estimate is only slightly higher than the number of animals actually sighted in November 1980.

Population Composition

Many studies do not distinguish between yearling females and adult females 2+ years of age (Anderson et al. 1974, Elliott 1982, Gogan et al. 1986). Consequently, the proportion of fawns in the population is presented in terms of both adult (2+ years) females and all females over one year (Table 5). Between 11 and 51 percent of the estimated population size was classified each month (Table 34). Composition counts for April, July and late November or early December were considered most representative (Dasmann and Taber 1956, Taber and Dasmann 1958). This study's November 1980 sample is probably the most accurate as it includes an estimated 51 percent of the total population at a time when both sexes are equally active and when virtually all fawns are at heel. In contrast, the September 1981 sample taken during the rut produced a high

Table 33. Weighted average and pooled estimates of group and individual density and total population size of black-tailed deer on Tomales Point derived from Fourier Series estimates for subsets of monthly samples with non-significant differences in mean group size.

		Group Size		No. of Terms in Fourier Series	f(0)		Group Density Estimate		Individual Density Estimate		Population Size	
Sample	N	$\hat{x}$	SE		$\hat{x}$	SE	$\hat{x}$	SE	$\hat{D}$	SE	$\hat{N}$	SE
Subset 1 - Weighted Average	114	2.06	0.16	-	-	-	0.058	0.010	0.12	0.02	123	21
Subset 1 - Pooled (Feb., Apr., May, July)	114	2.05	0.16	1	0.006	0.03×10^{-2}	0.054	0.013	0.11	0.03	113	31
Subset 2 - Weighted Average	242	2.25	0.09	-	-		0.080	0.011	0.18	0.03	185	31
Subset 2 - Pooled (Nov., Feb., May, July, Aug., Sept.)	242	2.25	0.09	4	0.007	0.08×10^{-2}	0.091	0.022	0.21	0.06	218	51
Subset 3 - Weighted Average	152	2.61	0.24	-	-	-	0.079	0.016	0.21	0.04	219	41
Subset 3 - Pooled (Nov., Dec., Feb. May)	152	2.61	0.24	1	0.008	0.03×10^{-3}	0.074	0.021	0.19	0.06	198	62
Subset 4 - Weighted Average	65	3.60	0.55	-	-	-	0.049	0.012	0.18	0.05	188	51
Subset 4 - Pooled (Dec., Jan., Feb.)	65	3.50	0.55	2	0.007	0.03×10^{-2}	0.047	0.008	0.17	0.04	175	41
Subset 5 - Weighted Average	162	2.21	0.11	-	-	-	0.097	0.012	0.21	0.03	216	31
Subset 5 - Pooled (N ≥ 40)	162	2.21	0.11	1	0.006	0.03×10^{-2}	0.097	0.012	0.21	0.03	218	31

Table 34. Population composition of black-tailed deer on Tomales Point determined by line transect sampling; percentages are given in parentheses.

Sample Period	Number Classified	Males		Females		Fawns	Males		Females		Fawns
		Adult	Yrling	Adult	Yrling		Adult	Yrling	Adult	Yrling	
Nov. 1980	141	20(14.2)	6(4.3)	64(45.4)	4(2.8)	48(34.0)	31	9	100	6	75
Apr. 1981	31	6(19.4)	4(12.9)	15(48.4)	4(12.9)	2(6.5)	40	26	100	26	13
May 1981	83	22(26.5)	9(10.8)	27(32.5)	10(12.0)	15(18.0)	81	33	100	37	56
Jul. 1981	35	8(22.9)	0(0)	16(45.7)	2(5.7)	9(25.7)	50	0	100	13	56
Aug. 1981	72	13(18.1)	7(9.7)	32(44.4)	0(0)	20(27.8)	40	21	100	0	63
Sep. 1981	120	45(37.5)	9(7.5)	39(32.5)	2(1.7)	25(20.8)	115	23	100	5	64

estimate for the proportion of adult males in the population. This is attributable to the incessant activity of males at that time. The May 1981 sample probably under-represents adult females, as they were then typically concealed in thick scrub with their neonatal fawns (Dasmann and Taber 1956, Taber and Dasmann 1958).

Fawns were sighted as early as April (1981) and their proportion to adult females increased through September. The proportion for November 1980 was the highest (Table 34) recorded. It is not known if this is the normal pattern or whether more fawns survived to six months of age in 1980 than 1981. The November 1980 and September 1981 ratio of fawns: 100 adult females agrees closely with ratios recorded at Hopland Field Station for November (Anderson et al. 1974) and with the ratios of fawns: 100 adult females in unburned chaparral in Lake County in December (Taber and Dasmann 1957, 1958). Recently burned and seeded chaparral had ratios of between 89 and 107 fawns: 100 adult females in December (Taber and Dasmann 1957, 1958). Ratios of fawns: 100 adult females for Tomales Point are higher than the 32 fawns: 100 does recorded in the pastoral zone in early December 1980 and the 33 fawns: 100 does in the southern section of the Seashore in September and November 1980 (Gogan et al. 1986). Thompson (1981) recorded a ratio

of 64 fawns: 100 adult females in the pastoral zone in January 1981.

No data were obtained on the sex ratio of fawns in this study. The sex ratio of 21 fetuses from 15 females collected in the pastoral zone between January and May from 1977 to 1980 was 62 males: 100 females. A chi-squared test shows this does not differ significantly from parity ($X^2 < 0.595$; $P \geq 0.10$). Sex ratios of fawns at birth in Lake County varied between 120 males: 100 females (Taber 1953) and 113 males: 100 females (Taber and Dasmann 1957, 1958). A ratio of 103 males: 100 females at birth was recorded for an unhunted population in Oregon (Hines 1975).

Survival of the cohort classified as fawns in November 1980, and as yearlings (11 months) in April 1981 is calculated from the method of Tranier et al. (1978):

$$R_{t1} - R_{t2}/R_{t1} = \%\ \text{loss} \qquad (12)$$

where R equals the ratio of the cohort: 100 adult does. In this case:

$$75 - 42/75 = 44\%\ \text{loss} \qquad (13)$$

However, as noted by Connolly (1981), any mortality of

adult females between t_1 and t_2 will increase the ratio of fawns: 100 adult females. As some adult female mortality is inevitable, the calculated loss of fawns represents a minimal estimate. The ratio of yearlings of both sexes to adult females in this study is far lower than in either the Lake County (Taber and Dasmann 1957, 1958) or Hopland populations (Anderson et al. 1974). In both these cases, where hunting would increase the rate of adult mortality, greater survival of young to the yearling age would be expected.

Shifts in the sex ratio between birth and one year reflect sex differential mortality (Taber and Dasmann 1954). The sex ratio of the 1980 cohort based upon the April and May 1981 samples is 93 males: 100 females. A chi-squared test shows this does not differ significantly from parity ($X^2 < 0.37$, $P \geq 0.10$). In the Lake County studies the sex ratio of yearlings was 64 males: 100 females (Taber and Dasmann 1954, 1958), with the exception of those animals occupying an area swept by wildfire, and therefore on a higher nutritional plane. There, the sex ratio approximated 100 males: 100 females (Taber and Dasmann 1958). The sex ratio in the Hopland population was estimated to be 83 males: 100 females (Anderson et al. 1974). In contrast, the sex ratio was 106 males: 100

females in an unhunted Oregon population (Hines 1975), where there was little or no sex-differential mortality against males until the cohort approached 20 months.

The sex ratio of adults on Tomales Point approximates the ratios of 30 to 39 males: 100 females reported for the Lake County population in the managed chaparral, but the proportion of males is lower than that reported for burned or unburned chaparral (Taber and Dasmann 1957, 1958). A ratio of 23 males: 100 females was reported for the hunted population on the Hopland Field Station (Anderson et al. 1974) and the unhunted population in Oregon (Hines 1975).

DISCUSSION

Differences in density estimates within both monthly and grouped samples probably reflect a combination of factors including but not limited to: 1) social organization; 2) seasonal movements of deer on and off the study area; 3) the effects of weather on detectability and, 4) the annual fawn crop. Deer tend to aggregate in larger groups from December through February, and thereby reduce the total number of groups present for detection. The months of March and April are characterized by persistent westerly winds of over 50 kph (Smith and Obreski 1971).

Deer detected at this period were frequently bedded down in east-facing canyons apparently attempting to escape the wind. This behavior would tend to counteract the effects of a reduction in group size. May is a transitional period with good visibility and little wind. During June, July and August Tomales Point is often bathed in advective fogs which frequently reduce visibility to less than 20 m, greatly hindering the detection of deer. The months of September, October, and November are characterized by fog-free days with little wind. These ideal conditions for detection of deer coincide with the rut (Dasmann and Taber 1956, Taber and Dasmann 1958) during which the males are almost continuously active and frequently move around the females. In addition, autumn marks the emergence of the year's fawn crop from areas of thick scrub. The percentage of fawns in the population was at a peak in November 1980 (Table 34), coincident with the highest population estimate. However, estimates of monthly adult population size only reduce the difference between highest and lowest estimates from a factor of 4.5 to 3 (Table 31). Local ranchers have long believed black-tailed deer on the Point Reyes Peninsula exhibit seasonal shifts in distribution, moving northward along the Peninsula in fall and southward in the spring (McDonald, pers. comm.). Whether such movements occur or the belief has been proposed to explain

seasonal differences in visibility of resident deer remains unknown. However, the possibility of ingress and egress from Tomales Point affecting density estimates cannot be ruled out. Black-tailed deer have been seen regularly swimming on both the Tomales Bay and Pacific Ocean side of Tomales Point. There is little doubt deer could swim around the game-proof fence.

Several of the monthly estimates of density tend to be low and have large standard errors. Such variability reflects use of samples with less than half the recommended sample size of 40. Pooling and weighted averaging raised the estimates of population size only slightly, but greatly reduced the standard error. The November 1980 census probably provides the most accurate estimate of black-tailed deer density and population composition.

Line transect sampling of black-tailed deer in the coastal prairie section of the Seashore's southern zone in the Fall of 1980 through 1982 produced annual density estimates ranging between 0.13 and 0.14 deer/ha and a pooled estimate for the 3 years of 0.14 deer/ha (Gogan et al. 1986). A single line transect census of black-tailed deer in the Seashore's pastoral zone immediately south of Tomales Point in December 1980 yielded a density estimate

of 0.21 deer/ha (Gogan et al. 1986), close to the December 1980 and September 1981 estimates for Tomales Point. Sample area counts (Dasmann and Taber 1955) of black-tailed deer on Tomales Point yielded an estimate of 0.31 deer/ha (Elliott 1982), higher than any of the point estimates derived from line transect sampling.

Calculations of black-tailed deer density based upon the known annual legal buck kill on the University of California's Hopland Field Station in Mendocino Co. yielded monthly estimates ranging from a peak in May of 0.37 deer/ha with 35 percent fawns to a midpoint of 0.30 deer/ha and 33 percent fawns in November and a low the following April of 0.24 deer/ha with 27 percent fawns (Anderson et al. 1974:29). The best estimate of population density on Tomales Point in November (0.29 deer/ha with 34 percent fawns) is strikingly similar to the November calculation for Hopland. On the other hand, point estimates of deer density on Tomales Point in other months are consistently lower than the calculations for Hopland (Fig. 33). The rate of harvest in the Hopland population was not considered sufficiently high to reduce deer density (Connolly 1981). The similarity in the November density estimates for the elk range and the Hopland site indicates the estimate of density from line transects is reasonable.

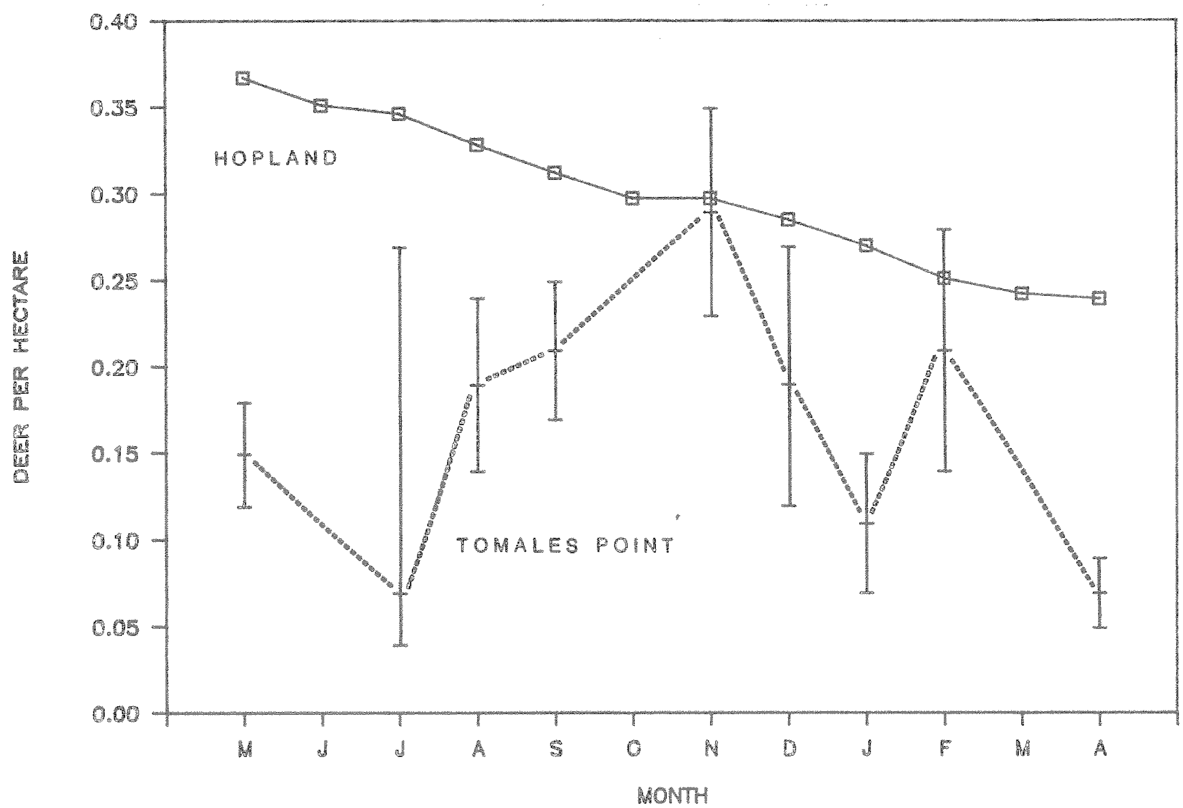

Figure 33. Comparison of black-tailed deer density estimates for Tomales Point and Hopland, California. Tomales Point data include bars representing plus or minus one standard error. Hopland data are estimates from a population model of black-tailed deer (Anderson et al. 1974:29).

The age and sex structure of a deer population can provide insight into the relationship of that population to its forage resources. Good forage conditions are reflected in high reproductive rates and high rates of survival, especially of fawns (Connolly 1981). In contrast, poor nutrition contributes to: 1) low reproductive rates; 2) poor fawn survival; and 3) a tendency toward a predominance of adult females in the population. Verme (1965, 1983) and McCullough (1979) note that white-tailed deer populations on a higher nutritional plane produce predominantly female offspring. If this pattern holds for black-tailed deer it suggests most populations studied are at a low nutritional plane, including the population on Tomales Point.

CONCLUSIONS

Direct observation from systematically allotted line transects is a suitable method for censusing and determining population composition of black-tailed deer on Tomales Point. However, the success of the sampling procedure is closely tied to the species' natural history and weather conditions. Sampling in November provided the best estimate of density (0.29 deer/ha) and population composition. Composition data reflect a population with a relatively low reproductive rate and low fawn survival.

Moreover, if the proportion of yearlings is an accurate measure of turnover in the adult segment of the population (i.e., the population is stable), the current turnover rate is very low and typical of a population fluctuating about ecological (food limited) carrying capacity.

CHAPTER XI

DENSITY OF BLACK-TAILED DEER FROM PELLET-GROUP COUNTS

Pellet-group counts provide an alternative to direct counts for estimating black-tailed deer density. Although pellet-group counts provide no information on population structure, they may provide equally accurate estimates of density without the constraints of daily and seasonal sampling imposed by direct counts.

METHODS

Black-tailed deer pellet-groups were counted along the 15.9 km of transect line established for line transect censuses of deer (Chapter X). All pellet groups of five or more pellets with a portion of the group lying within 0.75 m of either side of the transect line were tallied in 200 m intervals demarcated with 2 m rebar markers (300 m^2 plots). Each 200 m corresponds to the boundaries of a 4 ha cell classified to vegetative type (Chapter III). Sampling was standardized by having only one person (PJPG) conduct tallies.

Survivorship of pellet-groups was measured by placing a

surveyor's flag adjacent to each of the first five pellet groups encountered within each 200 m interval. The observer assessed whether the marked pellet-group was visible in the subsequent sample period. If not, the flag was removed and set at a previously unflagged pellet-group within the 200 m section, except in the few occasions no additional pellet groups were located. Lost flags were replaced. The rate of deposition (R) of pellet-groups per day for each 200 m section of transect was determined by:

$$R = N_{t+1} - (P\ N_t)/T \qquad (14)$$

where N_{t+1} is the number of pellet-groups counted at time t+1, P is the overall proportion of flagged pellet-groups visible at time t still visible at time t+1, and (1-P) represents an estimate of the "... disappearance of groups from the population ..." (Batcheler 1975:645). N_t is the number of pellet groups counted at time t, and T is the number of days between samples. Transects were first sampled in December 1980. Subsequent sampling was done in February, April, July and September 1981. No estimate of deer density was made from the initial count. It was used solely for pellet survival estimates.

Program PELANAL (Eberhardt and White 1980) was used to

test for differences in the mean rate of deposition of pellet-groups between vegetative types within sample periods. Groups with non-significant differences were combined, and the average observed rate of deposition was divided by the standard rate of pellet-group deposition of 13 pellet-groups per day (Rogers et al. 1958) to obtain an estimate of deer density. Density was multiplied by area to generate an estimate of deer population size.

RESULTS

The proportion of pellet groups visible between sampling periods remained fairly constant between February and July, but almost doubled in September (Table 35).

There were no significant differences detected in the mean daily rate of pellet-group deposition between vegetative types or pooled across vegetative types within any sample period (Table 36). However, there are several differences in mean pellet-group density within any vegetative type over time. Failure to detect significant differences may reflect inadequate sample sizes relative to the standard error. Changes in pellet-group frequency within vegetative types over time may indicate true differences in utilization patterns or other confounding

Table 35. Numbers and proportion of flagged pellet-groups judged to be visible in each sample period for all vegetative types combined.

Sample Period	No. Flagged	No. Visible	Percent Survival
Dec. '80-Feb. '81	243	109	45
Feb. '81-Apr. '81	148	53	36
Apr. '81-Jul. '81	97	40	41
Jul. '81-Sep. '81	149	115	77

Table 36. Pellet-group density per plot in 300 m^2 plots in each of four vegetative types and pooled for all vegetative types for each of four sampling periods.

Vegetative	February 1981			April 1981			July 1981			September 1981		
	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Open Grassland	16	0.06	0.09	16	0.07	0.07	12	0.08	0.17	13	0.12	0.18
Lupine Grassland	23	0.10	0.07	23	0.05	0.05	18	0.11	0.09	21	0.14	0.10
Baccharis Grassland	16	0.12	0.09	12	0.06	0.13	11	0.22	0.14	14	0.19	0.22
Thick Scrub	22	0.05	0.05	16	0.07	0.01	19	0.12	0.06	16	0.94	0.11
Pooled	77	0.08	0.03	67	0.06	0.05	60	0.13	0.01	64	0.13	0.04

factors. There is a gradual increase in pellet group density in the thick scrub type from February through July and a several fold increase in September. Deer may have utilized this type more frequently in the late summer as other vegetative communities dried, or the increase may reflect increased use of the transect lines cleared through thick scrub.

Estimates of mean deer density for each sample period range between 0.16 and 0.33 deer/ha (Fig. 34). Density estimates are highest for July and September and lowest for April.

DISCUSSION

Pellet-group distributions of cervids have been fitted empirically by the negative binomial distribution (Bowden et al. 1969, McConnell and Smith 1970, Stormer et al. 1977, Eberhardt and White 1980). The distribution is characterized by the mean frequency of pellet-groups/plot and a positive measure of dispersal (Eberhardt and White 1980, Rowland et al. 1984). Program PELANAL permits testing mean frequencies between populations by setting the measure of dispersal to a common value for all samples (Eberhardt and White 1980, Rowland et al. 1984). A minimum

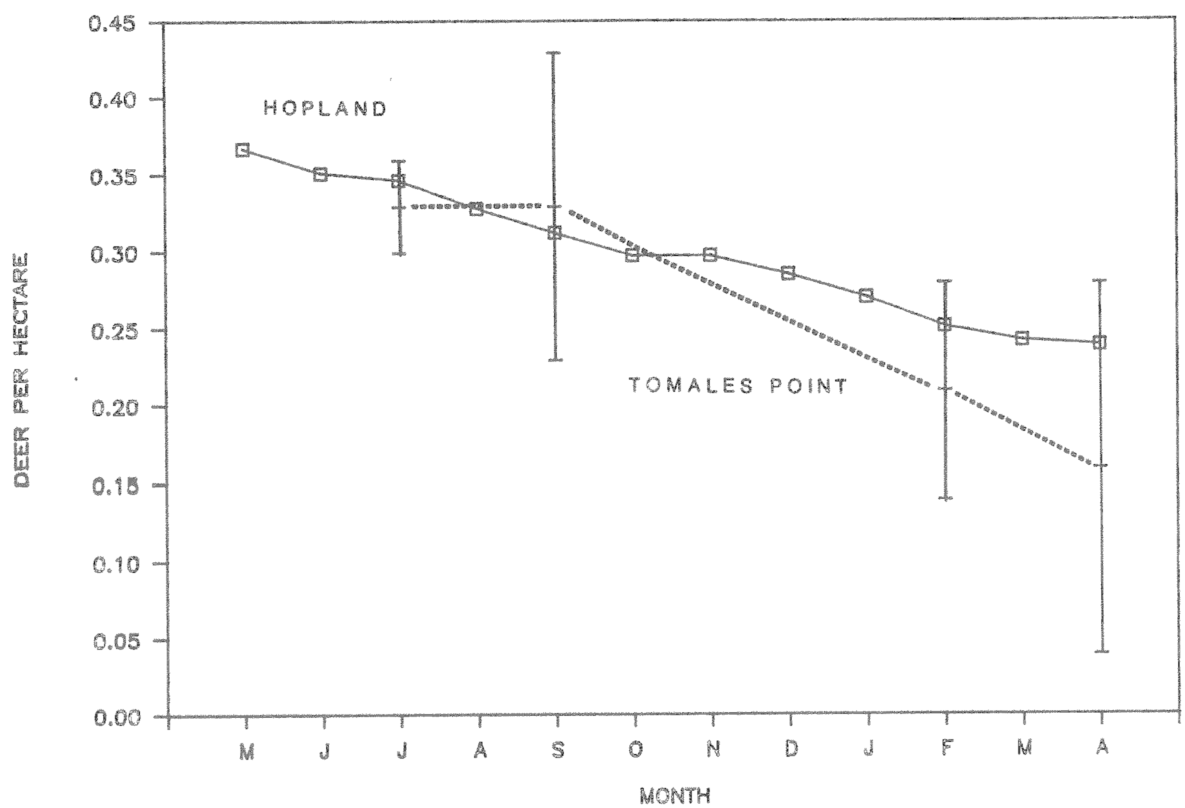

Figure 34. Comparison of black-tailed deer density estimates for Tomales Point and Hopland, California. Data are derived from pellet-group counts and include bars representing plus or minus one standard error. Hopland data are estimates calculated from a population model (Anderson et al. 1974:29).

sample size in excess of 30 plots is recommended for determining the confidence interval of an estimate of mean pellet group frequency/plot with program PELANEL (Eberhardt and White 1980). Sample sizes for specific vegetative types fall below the recommended minimum in all sample periods (Table 36).

The efficiency of pellet-group counts may be affected by the shape of the sample plot. Long, narrow plots such as used in this study are considered superior to squares of equal area (Neff 1968). Previous studies have marked individual pellet-groups to determine their rate of disappearance (Batcheler 1975).

The creation of transect lines may have modified the distribution of deer and hence pellet groups, especially in the thick scrub vegetative type (Table 36). Access to such areas was facilitated by clearing brush to permit passage of individuals single-file. Subjective observations suggest deer did not respond to these pathways. There was little "incentive" for deer to avoid the transect lines as they were traversed only once each month. Furthermore, deer are conditioned to the proximity of large numbers of Park visitors year round. Similarly, attraction of deer to

the transect lines was believed minimal. Patches of thick scrub are criss-crossed with a network of deer trails, most of which cut diagonally across steep slopes. Deer habituated to the use of such trails would not likely make extensive use of new pathways ascending and descending slopes without regard to slope. However, the possibility deer utilized the trails far more regularly between the third and fourth sample periods cannot be ruled out.

Inadequate sampling intensity probably contributed to the failure to detect differences in mean pellet-group frequency/plot between vegetative types. However, pooled samples for each sample period exceed the recommended minimum of 30 plots in all cases (Table 36), thus providing an adequate sample for an overall density estimate.

Daily defecation rates have been calculated for black-tailed deer ranging from 10-17 pellet-groups (Dasmann and Taber 1955). Defecation rates certainly vary with seasonal diet. However, in the absence of measured values the commonly accepted defecation rate of 13 pellet groups/deer/day is used.

Estimates of black-tailed deer density (Fig. 34) suggest higher population density in July and September

than February and April. Such differences would be even greater if higher defecation rates for the wet months of February and April were applied to the measured frequencies of pellet groups (Table 36). Higher density in September is consistent but out of phase with the high density recorded in November by direct observation (Chapter X). The observed pattern approximates the annual cycle of black-tailed deer density reported for Hopland Field Station, Mendocino Co. (Anderson et al. 1974), although the February and April estimates for Tomales Point are below those for Hopland (Fig. 34). The four estimates of black-tailed deer density derived from pellet group counts fall well within the range of density estimates obtained from replicate line transect censuses on Tomales Point (Chapter X) and other portions of the Point Reyes Peninsula (Gogan et al. 1986). The higher estimates of density from pellet group counts agree closely with an estimate of 0.31 deer/ha (Elliott 1982) derived from sample area counts (Dasmann and Taber 1955) on Tomales Point.

CONCLUSIONS

Pellet group counts provide a suitable means of determining density of black-tailed deer on Tomales Point. Sampling intensity was not adequate to detect differences,

if any, in density within vegetative types. Sampling in July provides a high estimate of density (0.33 deer/ha) with small standard error which agrees closely with the best estimate obtained from line transect censuses (Chapter X). Pellet groups may prove a more desirable means of monitoring deer numbers on Tomales Point as plots may be sampled during all daylight hours rather than just within a limited number of hours in the morning and evening, as is necessary with line transects. Although area counts on Tomales Point provide comparable estimates of density, they have a number of disadvantages including: 1) covering smaller areas (Elliott 1982); 2) assuming all deer utilizing an area are in open vegetation, and hence visible, during the sample period; and 3) providing no estimate of sample variance. Consequently, the method is not recommended.

CHAPTER XII

DENSITIES OF GRASSLAND RODENTS

At high densities, rodent populations have the potential to modify grassland standing crop, species composition and seed production in the California coastal prairie type (Batzli and Pitelka 1970). Knowledge of rodent densities on Tomales Point may permit inference as to these populations' impact on vegetation from studies of grassland rodents at other locales where vegetation and rodent community composition are equivalent. Measurements of rodent population densities on Tomales Point were obtained for this purpose.

METHODS

Mark-Recapture

Rodent population densities were measured on two 4-ha grid cells located on the portion of Tomales Point utilized by tule elk. Cells selected represented the lupine grassland type and open grassland type. Sampling was done in October 1980, and March and June 1981.

Trapping was tailored to permit analyses of results by

program CAPTURE (Otis et al. 1978). One hundred Sherman live traps (9 in.) were set out 20 m apart in a 10 x 10 m grid. A single trap was set at each location and baited with rolled oats. The traps were run for four consecutive nights for a total of 400 trap nights. Traps were set out in the late afternoon of the first day and checked the following morning. They were closed during the days and reset in the afternoon. Trapped rodents were individually marked by a pattern of toe clipping (Melchoir and Iwen 1965). The length of trapping period, time of day, and number of traps set were held constant at each trapping site and each trapping interval.

Runway Counts

Rodent runways were counted in three of the four vegetative types (lupine grassland, N = 7; open grassland, N = 7; and baccharis-grassland, N = 4) at locations simultaneously utilized for vegetation sampling. Eight 3-m transects were selected randomly in location and direction within 100 m of a permanently marked center point and all active rodent runways intersected by the transect tallied (Lidicker and Anderson 1962). Rodent density for each vegetative type was calculated by multiplying the mean

number of runways per vegetative type by 3.9 (Lidicker and Anderson 1962).

RESULTS

Mark-Recapture

Three species of rodents were caught in each grid: 1) California vole (_Microtus californicus_); 2) deer mouse (_Peromyscus maniculatus_); and western harvest mouse (_Reithrodontomys megalotis_). Only voles were caught with sufficient regularity to generate estimates of density (Table 37).

Criteria for data sets analyzed with program CAPTURE include: 1) a minimum of 5 trapping occasions with 7-10 preferred; 2) trapping at least 25 different individuals; and 3) a calculated capture probability (p) of at least 0.10 (Otis et al. 1978:78). In instances where trapping occasions are less than 10, at least 20 different individuals should be caught, and p should not be less than 0.30 (White et al. 1982:165). Thus, the trapping period of 4 days is below the recommended minimum. A minimum sample size of 20 separate animal captures was achieved for seven of the eight vole density estimates, but a minimal p of

Table 37. Number of individuals of three rodent species caught and released in two vegetative types on Tomales Point. Each sample period consisted of 400 trap nights on a 4-ha plot.

Vegetative Type	Date	Rodent Species		
		Vole	Deer Mouse	Harvest Mouse
Lupine grassland	Oct. '80	51	19	9
	Mar. '81	22	14	3
	Jun. '81	24	12	0
Open grassland	Oct. '80	52	23	8
	Mar. '81	15	3	7
	Jun. '81	33	6	4

0.30 was not achieved on any occasion (Table 38). Likely, this combination of factors contributes to the selection of the null model (M_0) within CAPTURE (Table 38) for most density estimates. This model assumes capture probabilities are constant throughout a trapping period, i.e., there is "no heterogeneity of capture probability, no behavioral response to capture, and no variation in the experimental situation over time" (Otis et al. 1978:21).

Runway Counts

Estimates of vole densities from runway counts (Fig. 35) are markedly higher than those obtained from mark-recapture sampling. The pattern of density fluctuation also differs between sampling methods: mark-recapture sampling indicates an increase in density between the March and June 1981 sample periods in both vegetative types. The runway counts suggest a decline in density over the same time period. A good correlation has been shown between vole density estimates obtained from runway counts and mark-recapture sampling elsewhere (Krohne 1982). There is no apparent reason for the lack of correlation in this case.

Table 38. Estimates of California vole density in two vegetative types by mark-recapture samples analyzed with program CAPTURE.

Vegetative Type	Date	N	Capture Model	p	Density No./ha	Density SE
Lupine grassland	Oct.'80	51	Mo	0.15	20.9	11.9
	Mar.'81	22	Mo	0.24	4.9	2.9
	Jun.'81	24	Mo	0.13	15.3	13.5
Open grassland	Oct.'80	52	Mo	0.22	2.7	5.4
	Mar.'81	15	Mo	0.24	1.9	3.5
	Jun.'81	33	Mh	0.15	12.7	5.9

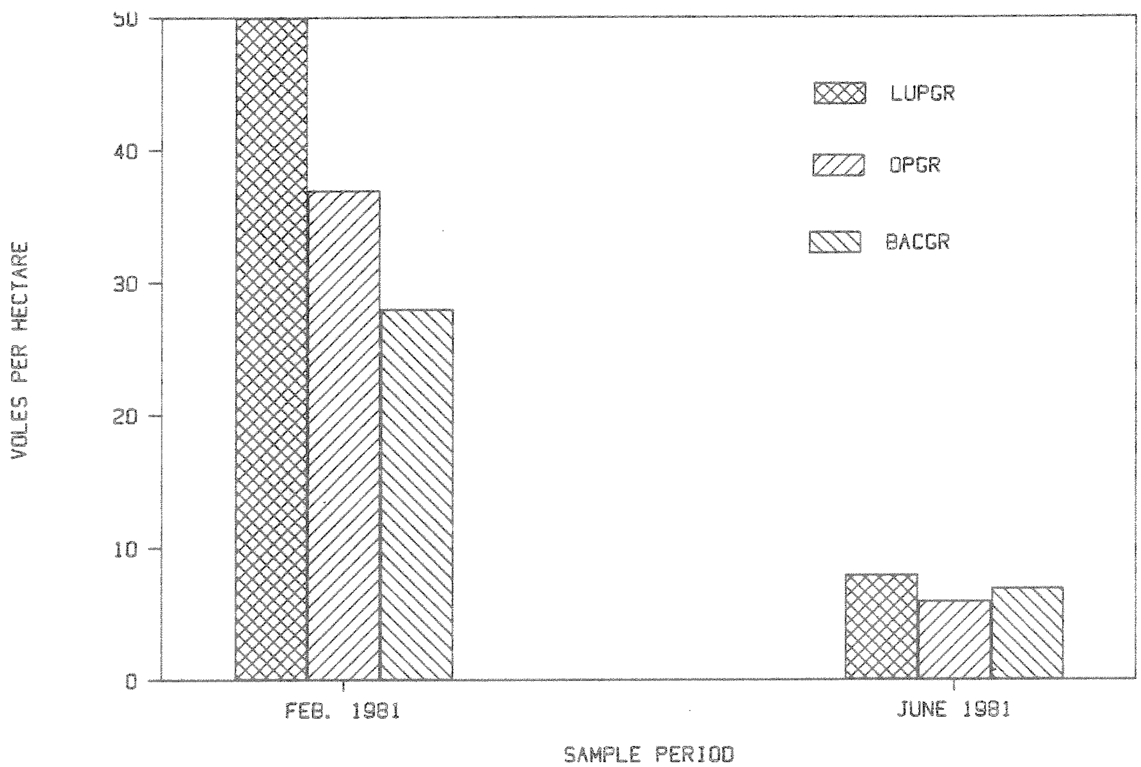

Figure 35. Densities of California voles in three vegetative types on Tomales Point determined from runway counts.

DISCUSSION

Simulation experiments show bias in estimates of numbers with program CAPTURE is low if p is at least 0.10 for at least five trapping occasions (Otis et al. 1978). Positive biases of 15-20 percent occur in instances where p is below 0.10 (Otis et al. 1978). In one instance, the heterogeneity in capture probability model (M_h) was selected (Table 38). Simulation experiments show that the estimate of numbers under model M_h has less bias than model M_o; however, confidence intervals under model M_h are generally unreliable (Otis et al. 1978).

Results suggest densities of voles on Tomales Point may reach high numbers, and vary by vegetative type and time. Intensive sampling of voles in a perennial grass, coastal prairie site free from livestock grazing at Sea Ranch, Sonoma Co. found densities consistently below 25/ha over a 5-year-period (Krohne 1982). Sampling in an annual grass, coastal prairie-coastal scrub mosaic at Bodega Head, Sonoma Co., free from livestock grazing for approximately 20 years, revealed densities varying by vegetative type from 14/ha to 127/ha, but remaining constant within each type for more than 3 years (Ostfeld and Klosterman, in press). However, vole populations have exhibited fluctuations

within the coastal prairie-coastal scrub type ungrazed by livestock on Brooks Island, Alameda Co. (Lidicker 1973).

CONCLUSIONS

Both mark-recapture and runway counts suggest vole population densities varying over time and among vegetative types. However, sampling procedures produce differing estimates of the magnitude and timing of population fluctuations. Findings of fluctuations in vole population density are consistent with studies of vole populations in some grasslands ungrazed by livestock within the coastal prairie-coastal scrub mosaic.

CHAPTER XIII

ELK AND DEER DIETS

Removal of livestock from and reintroduction of tule elk to the coastal prairie-coastal scrub mosaic of Tomales Point represents a major perturbation to the range-herbivore system. In time, a new equilibrium will develop with elk and deer as the dominant vertebrate herbivores. Dietary overlap leading to competition between elk and deer for forage resources may have important implications for the long-term carrying capacity of Tomales Point for both ungulate species. As noted previously (Chapter I), documented accounts of resource competition between elk and deer have favored elk. Dietary information gathered while elk are at low numbers and before deer numbers and the plant communities have responded to the removal of livestock should provide insight into optimal diets for both species as well as potential competition for forage resources in the future.

METHODS

Food Habits

Diets of elk and deer were determined by

microhistological identification of plant epidermal fragments in fecal material following the procedures of Sparks and Malacheck (1968) and Vavra and Holecheck (1980). A composite fecal sample ($n \geq 15$) (Anthony and Smith 1974) for elk was collected in mid-February and late May 1979 and in the middle of each month from October 1979 through April 1980. Sampling was intensified with collections at the middle and end of each month from late May 1980 through mid-September 1981. Composite fecal samples for deer ($n \geq 15$) (Anthony and Smith 1974) were collected in the middle of each month over all of Tomales Point from mid-December through mid-April 1980. Separate fecal samples were collected monthly for the southern and northern sections of Tomales Point, representing areas utilized and not utilized by elk, respectively (Chapter II), from mid-May 1980 through mid-September 1981. The bulk of the samples collected from mid-December through mid-April were collected in the southern portion of the study area and they are accordingly reported for this area.

Fecal samples were frozen until delivered to the Department of Forestry and Resource Management, University of California, Berkeley. There, they were oven-dried, and ground through a 1 mm screen. Each sample was bleached and stained with hematoxlin and safranin prior to mounting on

microscope slides in a gum arabic - karo syrup medium (Truman et al. 1983). Five slides were prepared for each sample and 20 fixed fields/slide were examined through a compound microscope at 100x. The frequency of each species was converted to an estimate of percent composition by dry weight (Hansen et al. 1977). A reference collection of plants on Tomales Point was supplemented with reference material from previous studies in the Seashore's pastoral zone (Elliott and Barrett 1985).

Dietary Overlap

Two indices were used to assess dietary overlap between elk and deer. The first is the simplest overlap index known (Hurlbert 1978) and may be represented as

$$C_{xy} = 1 - \tfrac{1}{2} \left(\left| \Sigma X_i + \Sigma Y_i \right| \right) = \min \left(X_i , Y_i \right) \qquad (15)$$

where X_i and Y_i are the percentages of the total diet of the herbivore species X and Y consisting of plant group i and s is the total number of plant groups (Schoener 1970). The resulting value is a percentage. This index has been used in a number of studies of dietary overlap in sympatric large herbivores (Anthony and Smith 1977, Leslie et al. 1984, Elliott and Barrett 1985) and has a number of advantages including: 1) ease of calculation; 2) freedom

from assumptions of the nature of any competitive process; 3) facilitation of intercommunity comparisons; and 4) it is not altered by subdivisions of dietary resources not recognized by the herbivores (Abrams 1980).

The second index is a measure of the probability ($\hat{C}_{\lambda}$) that a randomly selected forage item occurs in the diets of sympatric herbivores (Morisita 1959, Horn 1966), expressed as:

$$\hat{C}_{\lambda} = \frac{2\Sigma_{i=1}^{s} X_i Y_i}{\Sigma_{i=1}^{s} X_i^2 + \Sigma_{i=1}^{s} Y_i^2} \qquad (16)$$

The probability index ranges from 0 to 1 with the latter representing complete overlap (Horn 1966). This index also has been used in studies of dietary overlap (Schwartz and Ellis 1981, Leslie et al. 1984).

Dietary overlap was measured for elk and deer using the mid-monthly diets of elk and the south section diets of deer for all sample periods. Overlap was investigated at the plant species level.

Dietary Preference

Preference for specific dietary items was quantified by a linear food selection index which is the unweighted

difference in proportions:

$$L_i = r_i - p_i \qquad (17)$$

where r_i is the proportion of food item i in the diet and p_i the proportion of the same food item in the forage (Strauss 1979). Properties of the index include: 1) it ranges from -1 to +1 with positive values suggesting preference and negative values suggesting avoidance or inaccessibility; 2) the expected value for non-selective feeding is 0; 3) it only takes on extreme values in instances where a rare plant is eaten almost exclusively or an abundant plant is avoided; 4) it is defined for all values of r_i and p_i; 5) it is linear relative to r_i and p_i; and 6) it is distributed approximately normally (Strauss 1979:349).

Plant species' availability was determined by vegetation sampling (Chapter III). Calculations were made using diet information for mid-June 1980 and 1981 as these samples correspond most closely with vegetation sampling in both years. Forage availability was calculated as the mean occurrence of a species within a vegetative type multiplied by the proportion of the north or south section of Tomales Point covered by that type (Chapter III). The diets of deer in the south and the north section were compared to

the respective estimates of forage availability. Elk diet was compared to the calculated availability of forage species in the south section. Preference was assessed for all plant types and for all plant species contributing five percent or more to the mean diet of either herbivore species or the weighted botanical composition of the range.

RESULTS

Elk Diet

A minimum of 24 plant species made up at least five percent of the elk diet in two or more sample periods (Table 39). Grass species were more than half this total. Elk were provided dietary supplements of alfalfa and pelleted livestock feed between mid-October and mid-April of year 1 (1979-1980). The impact of supplements on dietary preferences is not known. Likely, most material in the supplements is listed as unknowns for each of the forage classes. Shrubs were eaten far more extensively in the fall and winter of 1979-1980 than any other time (Fig. 36). Elk fed more extensively on grasses in the fall-winter months and forbs in the spring-summer months, respectively, of year 1980-1981 than 1979-1980. The increased intake in grasses or forbs was offset by a

Table 39. Percent composition of taxa making up more than five percent of the elk diet in any two sample periods. The elk diet was sampled monthly from October 1979 through March 1980 and bimonthly from April 1980 through September 1981.

Taxon	Year	October		November		December		January		February		March		April		May		June		July		August		September	
		Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End
FORBS																									
Achilles	1[a]	0	-	1	-	0	-	1	-	13	-	2	-	1	-	2	0	0	8	0	2	1	1	0	0
borealis	2[b]	1	0	0	1	2	0	0	0	1	0	0	-	0	0	2	-	3	1	2	1	2	6	2	-
Erodium	1	0	-	0	-	0	-	3	-	2	-	tr[c]	-	0	-	-	11	11	3	tr	tr	tr	tr	tr	0
spp.	2	0	6	0	0	0	0	0	0	0	0	2	-	3	8	6	-	6	1	1	7	0	0	0	-
Iris	1	0	-	0	-	tr	-	tr	-	0	-	0	-	0	-	-	0	0	0	0	7	0	0	0	tr
douglasiana	2	1	0	0	0	0	0	0	2	8	1	1	-	tr	0	0	-	tr	0	0	1	0	0	0	-
Lobularia	1	4	-	tr	-	0	-	0	-	0	-	0	-	0	-	-	0	0	tr	0	2	5	7	2	tr
maritima	2	1	0	0	2	0	0	0	0	0	0	0	-	0	0	0	-	0	0	4	1	2	2	4	-
Montia	1	0	-	0	-	0	-	0	-	0	-	14	-	8	-	-	22	2	0	0	0	0	0	0	0
perfoliata	2	0	0	0	0	2	0	0	0	0	0	19	-	75	58	9	-	2	1	6	3	2	16	11	-
Plantago	1	2	-	tr	-	0	-	5	-	0	-	tr	-	2	-	-	6	11	18	0	4	10	4	4	4
lanceolata	2	3	0	tr	1	0	0	tr	0	1	1	18	-	6	20	61	-	33	56	31	32	15	13	11	-
Rumex	1	0	-	0	-	0	-	0	-	0	-	tr	-	tr	-	-	8	tr	0	tr	tr	tr	tr	26	12
spp	2	3	0	2	3	1	0	0	0	0	0	0	-	4	2	3	-	3	3	10	8	7	tr	0	-
Unknown	1	6	-	4	-	6	-	13	-	0	-	3	-	7	-	-	8	6	6	16	3	20	6	4	1
forbs	2	1	2	1	6	2	12	6	2	0	0	1	-	0	1	tr	-	3	0	1	2	0	1	4	-
Total	1	18	-	13	-	10	-	38	-	1	-	32	-	43	-	-	65	57	50	40	49	47	25	37	22
forb	2	16	3	7	14	6	2	8	9	17	6	49	-	94	92	83	-	64	87	75	72	48	48	51	-
GRASSES/SEDGES																									
Agrostis	1	0	-	0	-	3	-	0	-	1	-	0	-	8	-	-	0	11	4	5	7	0	9	13	0
diegoensis	2	2	8	2	5	2	5	2	0	0	0	0	-	0	1	0	-	0	0	2	7	1	0	0	-
Aira	1	0	-	0	-	5	-	0	-	0	-	1	-	0	-	-	0	0	0	0	0	0	0	0	0
caryophyllea	2	2	0	0	0	0	3	0	0	0	0	1	-	0	3	1	-	3	0	0	0	5	0	0	-
Bromus	1	0	-	0	-	0	-	4	-	2	-	3	-	3	-	-	3	tr	0	0	2	0	14	0	0
spp.	2	5	0	0	2	0	0	1	18	5	14	7	-	2	0	1	-	2	0	0	0	0	6	19	-
Danthonia	1	0	-	0	-	0	-	7	-	tr	-	2	-	0	-	-	0	0	0	0	0	0	0	0	0
californica	2	tr	0	0	0	0	0	0	6	0	1	0	-	0	-	0	-	0	0	0	0	0	tr	0	-
Festuca	1	0	-	0	-	23	-	10	-	2	-	5	-	1	-	-	0	1	2	0	tr	0	0	0	0
dertonensis	2	0	0	0	1	28	4	29	36	15	25	13	-	0	tr	0	-	3	0	0	3	tr	0	0	-

Table 39. Continued.

Taxon	Year	October		November		December		January		February		March		April		May		June		July		August		September	
		Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End	Mid	End
Festuca rubra	1	tr	-	0	-	0	-	0	-	0	-	0	-	0	-	-	0	0	0	0	0	0	0	0	0
	2	0	0	1	0	9	4	6	6	3	7	5	-	2	2	0	-	2	1	4	4	0	2	2	-
Holcus lanatus	1	0	-	0	-	tr	-	0	-	0	-	tr	-	9	-	-	1	tr	tr	0	2	4	9	1	26
	2	23	38	41	3	15	3	5	2	1	0	tr	-	0	0	0	-	1	0	0	2	15	25	16	-
Hordeum spp.	1	1	-	11	-	17	-	3	-	0	-	6	-	tr	-	-	5	0	2	0	1	0	0	0	4
	2	3	0	0	10	19	57	16	0	5	12	4	-	0	0	2	-	0	0	1	2	3	7	0	-
Juncus spp.	1	0	-	0	-	9	-	0	-	0	-	2	-	2	-	-	0	0	1	0	4	6	2	0	0
	2	1	4	8	1	1	1	1	1	32	2	5	-	0	0	tr	-	1	0	0	0	2	tr	tr	-
Lolium perenne	1	0	-	0	-	6	-	6	-	2	-	6	-	3	-	-	0	0	0	0	1	2	0	14	3
	2	0	12	6	0	2	6	1	0	0	9	0	-	0	0	0	-	0	0	0	0	0	2	7	-
Poa annua	1	0	-	0	-	0	-	5	-	1	-	2	-	5	-	-	0	0	2	0	0	0	0	0	0
	2	0	0	0	-	0	-	0	0	5	1	2	-	tr	0	0	-	0	-	0	0	0	2	0	-
Polypogon monspeliensis	1	0	-	0	-	0	-	0	-	5	-	4	-	0	-	-	0	0	0	0	0	0	0	0	0
	2	0	0	1	1	1	0	2	0	0	8	2	-	0	0	0	-	5	0	0	0	0	0	0	-
Unknown grass	1	0	-	22	-	12	-	0	-	5	-	5	-	13	-	-	19	28	31	18	5	12	16	15	14
	2	9	7	19	23	13	12	1	13	3	6	7	-	0	2	9	13	3	4	5	3	3	2	1	-
Total grass	1	7	-	33	-	76	-	40	-	25	-	41	-	56	-	-	34	41	42	23	26	32	55	50	46
	2	46	76	89	50	91	93	91	86	77	91	50	-	6	8	16	-	31	5	18	21	30	47	45	-
SHRUBS																									
Artemisia spp.	1	56	-	49	-	11	-	21	-	74	-	26	-	0	-	-	0	0	6	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	1	0	2	0	-	0	0	0	-	0	0	0	0	tr	1	0	-
Lupinus spp.	1	10	-	0	-	1	-	0	-	tr	-	0	-	0	-	-	1	0	1	0	1	13	11	2	13
	2	32	17	2	19	1	1	1	1	0	0	0	-	0	0	0	-	2	2	0	1	4	1	tr	-
Total shrub	1	76	-	50	-	12	-	22	-	74	-	26	-	0	-	-	1	0	7	1	18	13	11	2	17
	2	35	19	2	19	1	1	1	1	0	2	0	-	0	0	0	-	5	5	5	6	17	3	3	-
TREES																									
Salix hindsiana	1	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	0	tr	tr	36	4	4	7	0	13
	2	2	tr	0	0	0	0	0	0	0	0	0	-	0	tr	tr	-	0	3	3	2	2	tr	3	-
Total tree	1	0	-	2	-	2	-	0	-	0	-	0	-	0	-	-	1	1	1	36	5	5	8	12	15
	2	3	1	2	17	0	2	0	2	5	0	0	-	0	tr	tr	-	0	3	3	2	2	2	tr	-

[a]Year 1 = October 1979 - September 1980.
[b]Year 2 = October 1980 - September 1981.
[c]tr < 2%.

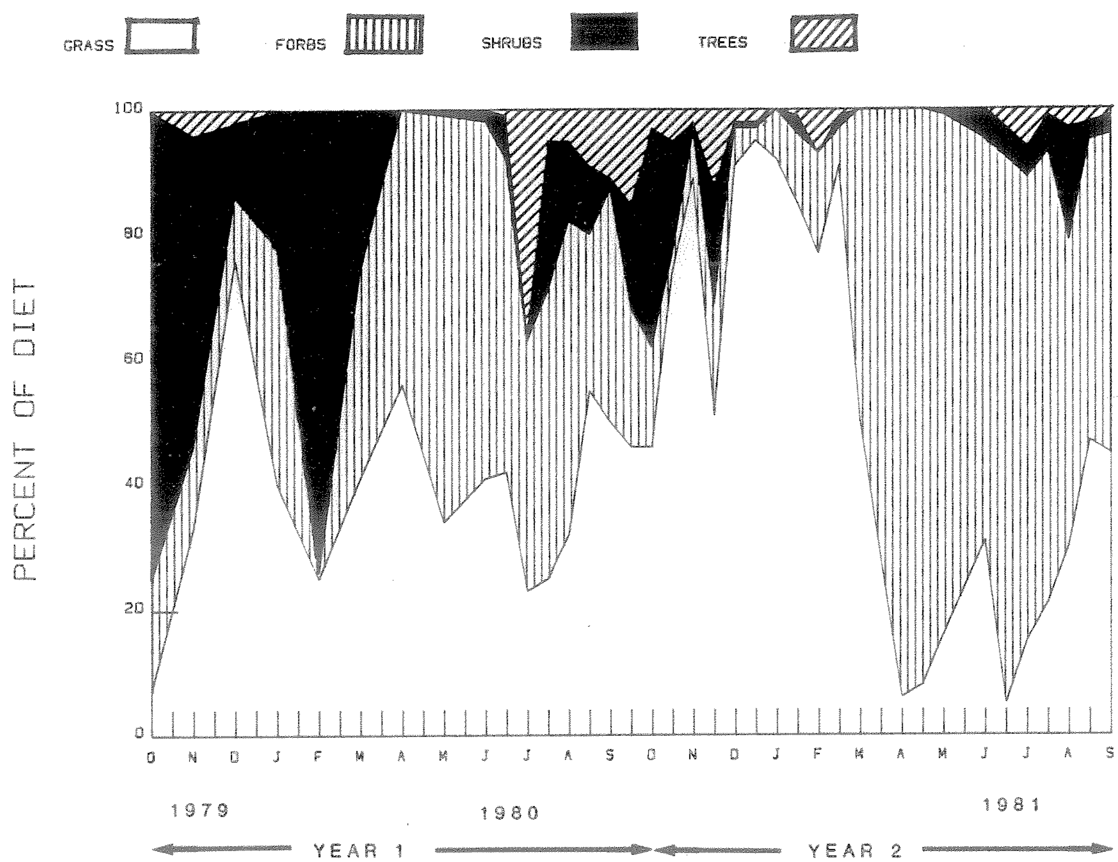

Figure 36. Elk use of forage classes determined by monthly samples from October 1979 through March 1980 and bimonthly samples from April 1980 through September 1981.

decline in the three other plant categories. The bulk of the forbs eaten in both years were English plantain (Plantago lanceolata) and miner's lettuce (Montia perfoliata), with the former taken predominantly from March to September and the latter for the relatively short period of March through May in both years (Table 39). Coast sagebrush (Artemisia californica) was consumed extensively in the winter months of 1979 but not at other times. Bush lupine (Lupinus arboreus) was the only other shrub taken by elk (Table 39). Trees were sandbar willow (Salix Hindsiana) in June and July of 1980 (Table 39) and Monterey cypress (Cupressus sargentii) in November of 1980 (Appendix II).

A study of the food habits of elk on Tomales Point from late September through December 1978 using the bite count method revealeda rapid transition from a diet of predominantly forbs to one of predominantly grasses in the first week of December (Ray 1981:98). Grass intake increased markedly between October and December 1979 (Fig. 36). However, in 1979 this study showed the transition was from shrubs to grasses, not forbs to grasses as recorded by Ray (1981). There was a rapid transition from grasses to forbs at the end of the winter 1981 (Fig. 36).

The diet of tule elk in the Owens Valley, Inyo Co. (McCullough 1969), is similar to that at Point Reyes in extensive use of forbs in the spring and summer. Browse is an important part of the summer diet in the Owens Valley (McCullough 1969) in contrast to Point Reyes. Willows were eaten in the summer at Point Reyes but in the winter at Owens Valley (McCullough 1969). Grasses make up more than 50 percent of the diet of tule elk in the Diablo Range, Contra Costa Co., in all seasons (Phillips 1985), and of Roosevelt elk in Prairie Creek Redwoods State Park, Humboldt Co. (Harper et al. 1967). In contrast, Roosevelt elk of the Olympic Peninsula of Washington consume a maximum of 26 percent grasses in the fall (Leslie et al. 1984).

Deer Diet

A minimum of 25 plant species made up at least five percent of the deer diet in two or more sample periods (Table 40). Browse plants were predominant (Table 40). The general dietary pattern shows a decline in the use of forbs from a peak in the spring to a low in the fall months with a concurrent increase in shrub use, reaching a peak in the fall months (Fig. 37). The decline in forb consumption is more continuous in the south section than north section.

Table 40. Percent composition of taxa making up more than five percent of the deer diet in the north and south sections of Tomales Point in two sample periods. The deer diet was sampled monthly from December 1979 through September 1981.

Taxon	Year	October		November		December		January		February		March		April		May		June		July		August		September	
		S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
Achillea	1[a]	-	-	-	-	2	-	-	-	13	-	1	-	4	-	0	2	2	2	tr	4	1	2	5	0
borealis	2[b]	6	5	0	tr[c]	2	2	1	0	36	11	2	1	3	1	2	4	tr	2	8	5	28	22	10	12
Cirsium	1	-	-	-	-	0	-	-	-	1	-	0	-	0	-	0	15	0	0	5	5	0	5	4	0
spp.	2	0	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iris	1	-	-	-	-	tr	-	-	-	0	-	0	-	0	-	0	0	0	0	0	0	0	0	0	0
douglasiana	2	0	0	0	10	0	1	0	6	0	16	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Lobularia	1	-	-	-	-	0	-	-	-	0	-	0	-	0	-	0	0	0	0	tr	0	2	0	3	8
maritima	2	2	0	0	11	9	2	1	0	0	0	0	0	0	0	0	0	0	0	tr	0	tr	tr	0	0
Montia	1	-	-	-	-	0	-	-	-	0	-	8	-	8	-	13	1	tr	1	3	1	0	0	0	0
perfoliata	2	0	0	0	0	0	0	0	0	9	2	20	60	12	41	17	11	0	tr	0	2	0	1	0	28
Plantago	1	-	-	-	-	0	-	-	-	0	-	4	-	61	-	47	21	69	71	30	11	31	12	9	2
lanceolata	2	2	2	0	3	2	0	3	0	9	15	69	1	70	42	60	44	63	73	41	53	20	19	24	31
Potentilla	1	-	-	-	-	0	-	-	-	2	-	8	-	0	-	0	0	0	0	0	tr	0	0	26	11
spp.	2	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	tr	0	0	0	0	0	0	0	0	2
Rumex	1	-	-	-	-	0	-	-	-	0	-	5	-	1	-	2	0	21	14	6	5	3	2	0	0
spp.	2	0	0	0	0	0	tr	0	4	0	0	tr	17	1	2	3	1	tr	12	16	25	4	6	0	9
Unknown	1	-	-	-	-	tr	-	-	-	3	-	2	-	2	-	7	10	1	3	13	6	10	0	3	14
forbs	2	4	3	2	5	8	4	8	2	0	2	tr	9	tr	0	tr	3	tr	1	tr	1	2	1	1	2
Total	1	-	-	-	-	10	-	-	-	25	-	47	-	88	-	76	61	94	92	72	59	56	34	56	60
forb	2	17	22	4	41	25	10	16	13	60	53	94	89	92	90	90	71	68	92	68	91	75	76	50	86
GRASSES/SEDGES																									
Bromus	1	-	-	-	-	tr	-	-	-	3	-	11	-	1	-	2	2	0	0	0	tr	0	0	0	0
spp.	2	tr	0	0	0	0	0	1	2	9	3	tr	tr	tr	0	0	tr	tr	0	0	0	tr	tr	0	0
Festuca	1	-	-	-	-	21	-	-	-	7	-	14	-	tr	-	1	0	0	0	tr	0	0	0	0	0
dertonensis	2	0	0	0	6	3	2	tr	10	tr	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0
Festuca	1	-	-	-	-	2	-	-	-	17	-	0	-	tr	-	0	0	0	0	0	0	0	0	0	0
rubra	2	0	0	0	0	tr	0	0	0	3	5	0	0	tr	0	0	0	0	0	0	tr	0	0	1	3
Unknown	1	-	-	-	-	3	-	-	-	0	-	2	-	2	-	5	1	1	1	tr	6	6	3	4	4
grass	2	tr	tr	tr	4	3	3	4	3	2	7	tr	0	tr	tr	2	2	2	tr	4	1	3	tr	0	tr
Total	1	-	-	-	-	34	-	-	-	31	-	41	-	7	-	14	10	2	2	4	8	8	8	5	5
grass	2	1	1	1	18	10	5	9	21	28	29	2	2	2	6	4	6	2	tr	4	2	4	2	2	3

Table 40. Continued.

Taxon	Year	October		November		December		January		February		March		April		May		June		July		August		September	
		S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
SHRUBS																									
Artemisia	1	-	-	-	-	4	-	-	-	1	-	0	-	1	-	1	0	0	tr	0	10	4	24	4	0
spp.	2	0	0	7	0	3	18	11	20	1	9	0	0	2	0	tr	0	0	0	0	0	7	5	32	0
Baccharis	1	-	-	-	-	6	-	-	-	0	-	0	-	0	-	0	tr	0	0	0	0	0	0	0	0
pilularis	2	0	7	1	1	3	7	8	14	tr	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceanothus	1	-	-	-	-	0	-	-	-	0	-	0	-	0	-	0	0	0	0	0	0	0	0	0	0
thrysiflorus	2	0	0	0	0	11	11	4	0	1	0	0	0	tr	1	0	0	0	0	0	0	0	8	0	0
Lupinus	1	-	-	-	-	9	-	-	-	30	-	4	-	3	-	2	25	2	3	tr	12	21	14	24	29
spp.	2	56	35	29	38	20	13	31	19	11	1	tr	5	3	tr	3	18	3	2	0	1	7	6	7	3
Lonicera	1	-	-	-	-	12	-	-	-	0	-	0	-	1	-	0	0	0	1	0	0	0	0	0	0
spp.	2	0	0	0	0	0	3	0	0	5	0	0	0	0	0	0	0	10	tr	0	0	0	0	0	0
Rhamnus	1	-	-	-	-	4	-	-	-	0	-	0	-	0	-	0	0	0	0	0	0	0	0	4	0
californica	2	0	0	1	0	0	5	7	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhus	1	-	-	-	-	0	-	-	-	0	-	5	-	0	-	0	0	0	1	0	0	3	18	0	0
diversiloba	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	tr	0	0
Rubus	1	-	-	-	-	1	-	-	-	0	-	0	-	1	-	0	0	0	tr	0	2	0	2	0	10
spp.	2	3	4	7	0	7	2	6	0	0	1	2	0	0	1	1	2	0	0	20	1	0	tr	0	4
Unknown	1	-	-	-	-	4	-	-	-	0		0	-	0	-	0	4	0	tr	0	0	0	0	3	0
shrub	2	6	1	5	0	0	0	0	TR	0	0	0	TR	0	0	0	2	0	0	0	TR	0	0	0	0
Total	1	-	-	-	-	46	-	-	-	33	-	9	-	5	-	11	30	2	5	6	27	30	58	36	33
shrub	2	76	59	86	41	48	73	67	62	19	17	3	6	6	3	6	23	27	5	25	5	16	22	43	7
TREES																									
Cupressus	1	-	-	-	-	5	-	-	-	11	-	0	-	0	-	0	0	0	0	0	0	0	0	0	1
sargentii	2	0	12	0	0	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Myrica	1	-	-	-	-	3	-	-	-	0	-	4	-	tr	-	0	0	0	0	0	0	2	tr	0	0
californica	2	1	4	8	0	1	7	6	3	0	0	0	0	0	1	0	0	0	0	tr	0	0	1	0	0
Salix	1	-	-	-	-	1	-	-	-	0	-	0	-	0	-	0	0	tr	1	15	4	2	tr	0	1
hindsiana	2	2	1	tr	0	2	1	0	3	0	0	0	0	0	0	0	0	3	3	2	2	tr	5	2	3
Total	1	-	-	-	-	9	-	-	-	11	-	4	-	tr	-	0	0	tr	1	15	4	4	1	tr	2
tree	2	4	16	8	0	15	10	6	3	0	0	0	0	0	1	0	0	3	3	3	2	1	6	2	3

[a]Year 1 = October 1979 - September 1980.
[b]Year 2 = October 1980 - September 1981.
[c]tr < 2%.

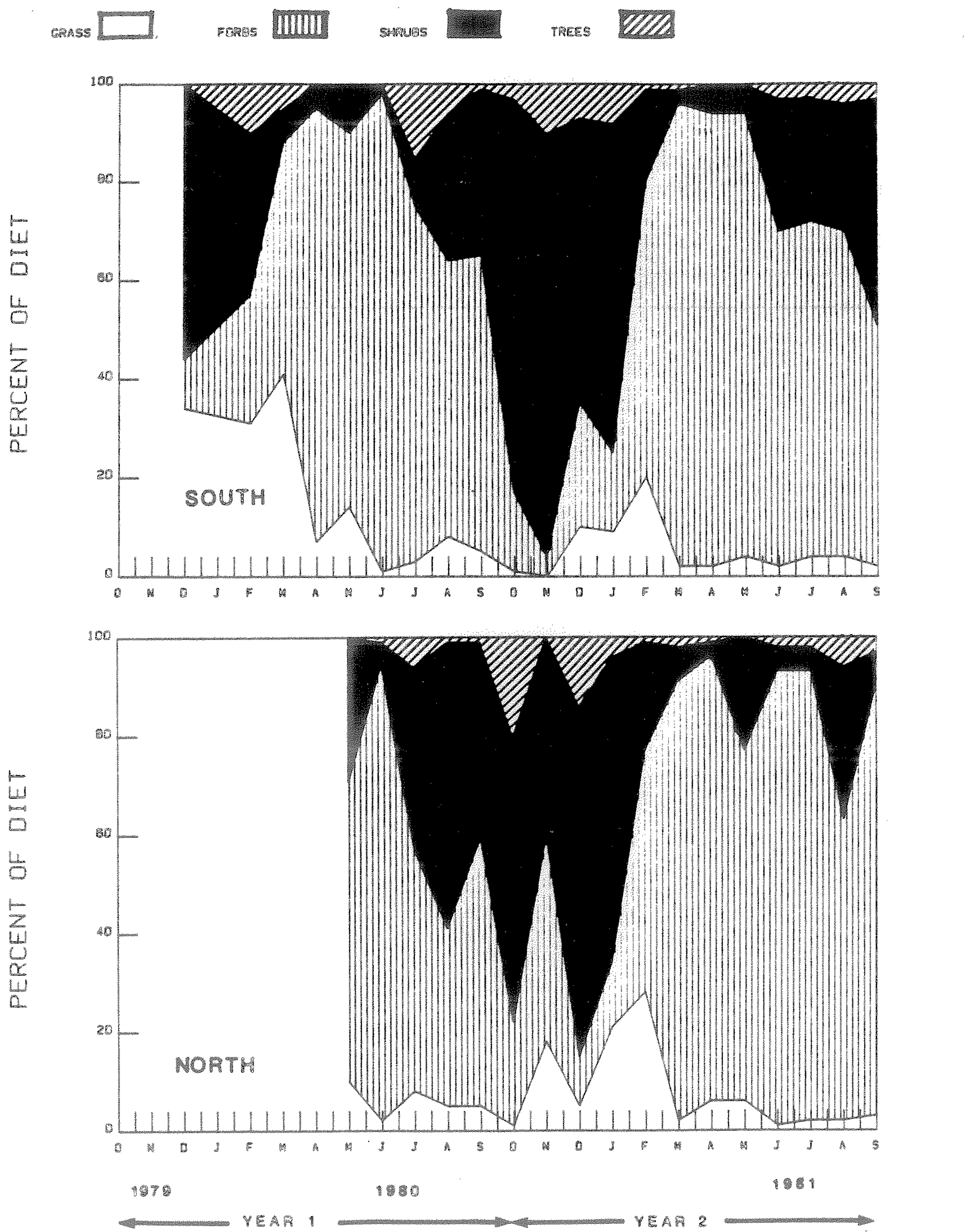

Figure 37. Deer use of forage classes determined by mid-monthly samples from December 1979 through September 1981 in the southern section of Tomales Point and from May 1980 through September 1981 in the northern section.

In both sections English plantain was taken from March to September and miner's lettuce from March through May in both years (Table 40). Yarrow (Achillea borealis) was consumed in all months with peaks in February of both years and a second peak in August and September 1981 while sheep sorrell and curly-leaved dock (Rumex spp.) were taken in only June and July of both years. And thistles (Cirsium spp.) were eaten only in 1980. Among the shrub species, bush lupine was taken predominantly from August 1980 through February 1981 with a second peak in May at the north section in both years (Table 40). Other shrubs such as poison oak (Rhus diversiloba) were consumed sporadically (Table 40). Three tree species were eaten in the fall and winter (Table 40).

Black-tailed deer on Tomales Point consume far more shrubs (Fig. 37) than do those in the Seashore's pastoral zone immediately to the south (Elliott and Barrett 1985:437). Similarities in dietary patterns between deer in both areas include the maximum consumption of grasses in the winter months and the maximum consumption of forbs in the summer (Fig. 37, Elliott and Barrett 1985). Dietary patterns of deer in other areas of central California are characterized by heavy reliance on browse throughout the

year with some intake of forbs in the late winter and spring (Taber and Dasmann 1958, Longhurst et al. 1979). Similarly, black-tailed deer of the Olympic Peninsula, Washington utilize browse extensively but use forbs in the summer months (Leslie et al. 1984).

Dietary Overlap

The degree of common use of plant species varied markedly between elk and deer. Both indices of dietary overlap show that the diets were most similar in July, August, and October 1980 and May through August 1981, with very high overlap in May 1981 (Fig. 38). Horn's (1966) formula tends to produce higher and lower estimates of dietary overlap at extremes than does the simple overlap index. The greatest degree of overlap coincided with extensive use of English plantain by both species (Tables 39 and 40).

Simple dietary overlap indices for elk and deer on Tomales Point (Fig. 38) were far more variable throughout the year than similar indices for six possible combinations of sympatric ruminants in the Seashore's pastoral zone

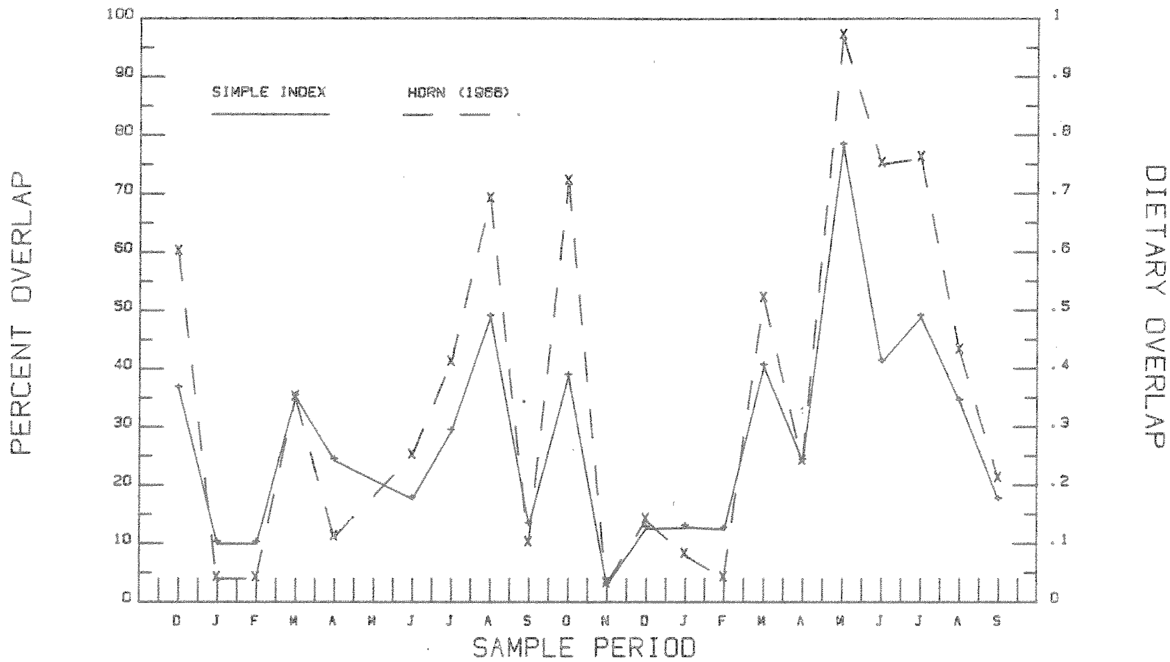

Figure 38. Two indices of monthly dietary overlap of elk and deer utilizing the south section of Tomales Point between December 1979 and September 1981.

(Elliott and Barrett 1985:438), or for sympatric elk and deer on the Olympic Peninsula, Washington (Leslie et al. 1984:768).

Diet Selection

Strauss index values for plant species making up more than five percent of the diet or five percent of the available vegetative cover show relatively few species were selected for by either herbivore. Elk showed a preference for two forb species and one grass species while deer selected for three forb species in at least one year (Table 41). The greatest degree of selectivity was exhibited by deer for English plantain. With the exception of selection for thingrass (Agrostis diegoensis) by elk in 1980, both herbivores avoided grasses, shrubs and trees with the avoidance of grasses by deer being most pronounced (Table 41). Plant species preferred by elk and deer on Tomales Point are largely the same species comprising a substantial part of the diet of four sympatric ruminants on the Seashore's pastoral zone (Elliott and Barrett 1985).

DISCUSSION

The value of fecal sample analysis to determine

Table 41. Strauss index values for diet selection of elk and deer for plant species making up five percent or more of any vegetative type or of either herbivore diet for June 1980 and 1981.

Taxon	Elk		Deer			
			South		North	
	1980	1981	1980	1981	1980	1981
LOWER PLANTS						
Pteridium aquilinum	-0.06	-	-0.06	-	-0.05	-
FORBS						
Erodium spp.	0.11	0.06	0.00	0.00	0.00	0.00
Heracleum lanatum	-	-0.15	-	-0.15	-	-0.14
Myrica californica	-0.04	-	-0.04	-	-0.04	-
Plantago lanceolata	0.00	0.11	0.58	0.41	0.60	0.52
Rumex spp.	-0.09	-0.18	0.12	-0.18	0.03	-0.10
Sambucus callicarpa	-	-	-	0.11	-	0.03
GRASSES/SEDGES						
Agrostis diegoensis	0.11	-	0.00	-	-	-
Aira caryophyllea	-0.17	-0.25	-0.17	-0.28	-0.16	-0.26
Bromus spp.	-0.32	-0.42	-0.32	-0.44	-0.38	-0.44
Festuca dertonensis	-0.26	-0.32	-0.27	-0.35	-0.31	-0.38
Lolium multiflorum	-0.06	-	-0.06	-	-0.08	-
Lolium perenne	-0.30	-0.22	-0.30	-0.22	-0.31	-0.23
SHRUBS						
Baccharis pilularis	-0.13	-0.25	-0.13	-0.25	-0.11	-0.21
Rhus diversiloba	-0.09	-0.14	-0.09	-0.14	-0.06	-0.12
TREES						
Salix Hindsiana	-0.04	-0.02	-0.05	-0.02	-0.03	-0.02

herbivore food habits has been scrutinized by a number of investigators. A recent review (Holechek et al. 1982) concluded that fecal analysis tends to underestimate the proportion of forbs in the diet of a variety of ruminants although some studies have reported this not to be the case (Todd and Hansen 1973, Anthony and Smith 1974, Kie et al. 1980). Elk digest forbs at a higher rate than other plant types while grass species vary in their digestibility (Pulliam and Nelson 1979). Digestibility of plant types is influenced by phenological phase (Pulliam and Nelson 1979). Leslie (1983) found seasonal variation in digestibility, with forbs, grasses and shrubs consistently underestimated in the diet of Roosevelt elk. Any inaccuracy in assessment of dietary intake of elk and deer on Tomales Point should be consistent between herbivores, and would tend to underestimate preference for forbs.

Deer on Tomales Point may be classified as forb-shrub feeders and elk as forb-grass feeders. Black-tailed deer are classified as intermediate feeders (Anderson and Wallmo 1984). Elk are generally considered grazers and the high use of forbs by elk on Tomales Point is somewhat atypical (Nelson and Leege 1982), although tule elk in the Owens Valley make extensive use of forbs in the spring and summer (McCullough 1969). The greatest partitioning of forage

species between elk and deer occurs in the wet winter and spring period when the grasses and shrubs taken by each are likely most palatable but plant biomass is low (Chapter III). The greatest dietary overlap occurs in the dry summer when forage quality is low but standing crop is high. Forbs are the most abundant plant type in the three grassland types in June (Chapter III). As noted by McCullough (1969) for tule elk in the Owens Valley, utilization of forbs in the spring provides nutritious forage at the onset of calving, molting and antler regrowth. This is true for both elk and deer on Tomales Point.

Both ungulates make extensive use of select plant species, notably English plantain, miner's lettuce and lupines. Plantain characteristically remains green during the summer and into the fall when most other plants are dry. Black-tailed deer also selected this species in the Seashore's pastoral zone in September (Elliott and Barrett 1985). Miner's lettuce is preferred by both species when available. Bush lupine is an important dietary item for both herbivores, especially in the fall, but more so for deer than elk. Utilization of plantain and miner's lettuce may directly affect trace element balances in elk and deer. Levels of copper in plantain at Point Reyes are low

(Akeson et al. 1982) relative to values from England (Thomas and Thompson 1948). Levels of molybdenum were higher in miner's lettuce than any other plant species tested on Tomales Point (Akeson et al. 1982). Deer utilization of shrubs in the fall and winter may ameliorate this situation. Shrub species tested on Tomales Point, including lupine, were higher in copper than all other plant types except wetland forbs (Akeson et al. 1982). The pontential impact of diet on hypocuprosis in elk is discussed in Chapter V. Utilization of lupines may expose both herbivores to teratogenic alkaloids (Keeler et al. 1977, Keeler 1978). Such alkaloids were identified as a possible cause of deformity in a stillborn elk calf (Chapter VII, Gogan and Jessup 1985). There are no records of deformities among deer fawns at Point Reyes.

Two schools of thought exist on ungulate diet selection. The first maintains that forage species are equal in food value and the feeding strategy should be to select food items in proportion to their availability (Pulliam 1974). The second school argues that forage species are unequal in food value and that the preferred feeding strategy is to optimize nutrient intake (Westoby 1974, Belovsky 1978). In the latter case, ungulates will select preferred forage items when resources are abundant

(Westoby 1974, Belovsky 1978). Dietary selection may be modified by the density of other members of the species population or of other sympatric ungulates species. McCullough (1980:4) has suggested that intraspecific competition tends to spread the use of the resource base while interspecific competition narrows it. These interactions are likely to come into equilibria with one another and the forage resources over time (Caughley 1976:214).

The measure of dietary overlap in this study reflects forge intake immediately following a large perturbation to the range-herbivore system, i.e., removal of domestic stock and reintroduction of tule elk. Elk numbers were well below carrying capacity in 1980 and 1981. Deer numbers were probably at equilibrium with livestock and forage resources prior to removal of cattle. The impact of removal of livestock on black-tailed deer is unknown. Studies of sympatric livestock and black-tailed deer in the pastoral zone suggest little direct overlap in diet (Elliott and Barrett 1985). However, the forage base has been subjected to over 100 years of intensive livestock use (Chapter II). Livestock utilization of the range coupled with introductions of exotic plant species has undoubtedly affected the forage resources available to ungulates. The

relationship of elk and deer on Tomales Point relative to any ecological balance in pristine times is remote. Firstly, the area's botanical composition has been altered dramatically. Secondly, elk may not have been year-round residents of Tomales Point in pristine times.

Studies of herbivore diets at different population densities are uncommon. White-tailed deer (O. virginianus) at high densities in southern Texas utilized more grasses than did deer in adjacent areas (Kie et al. 1980). Similarly, the diet of elk and deer on Tomales Point may change as elk density increases. One would expect increased use of less preferred forage items as intra- and interspecific competition intensifies with the growth of the elk population.

Strauss index values show both elk and deer on Tomales Point clearly preferred certain forages and avoided others (Fig. 38) in June of 1980 and 1981, the time of peak herbaceous standing crop (Chapter III). The rapid transition in classes of forage consumed by both herbivores also indicates selectivity. Thus, the nature of forage selection by both elk and deer supports the theory of optimal nutrient intake (Westoby 1974, Belovsky 1978). Both elk and deer showed a high preference for three forage

species (Table 41). The highest degree of selectivity was exhibited by deer for English plantain. Greater selectivity by deer is in accord with the hypothesis that smaller ungulates are more selective than large (Holechek et al. 1982). Plantain is used extensively by both herbivores and it may be an important source of certain nutrients in the dry months. Any competition for forage resources may center on this species as elk numbers increase on Tomales Point. In addition, plantain is most abundant in disturbed areas on Tomales Point -- formerly cultivated fields and areas grazed heavily in the past. Successional changes may lead to a reduction in the abundance of plantain independent of the effects of grazing by elk and deer.

Black-tailed deer (O. h. sitkaensis) in southwest Alaska feed upon beach kelp (Fucus sp.) in severe winters (Klein and Olson 1960), and red deer (C. e. elaphus) on the Isle of Rhum, Scotland take seaweed regularly each winter (Clutton-Brock et al. 1982). A variety of species of marine flora, particularly bull kelp (Nereocystis leutkeana) and eelgrass (Zostera marina), wash ashore on the beaches of Tomales Point following winter storms. Small amounts of these species were taken by elk and deer during this study (Appendix II). Possibly, they may become

more important as elk numbers increase.

CONCLUSIONS

Elk and black-tailed deer on Tomales Point may be classified as forb-grass and forb-shrub feeders, respectively. Both utilize forbs extensively in the spring and summer months when herbaceous standing crop is at a maximum, and resort to other plant types when they are likely more nutritious in the fall and winter. Thus, both herbivores exhibit a pattern of optimizing nutrient intake. Measurement of forage selectivity in June of 1980 and 1981 shows: 1) elk and deer are highly selective in species taken; 2) deer tend to be more selective than elk; and 3) some plant species are selected by both herbivores. Both herbivores make extensive use of English plantain, an exotic perennial forb that remains green for much of the dry season. At this time, although herbaceous standing crop is high most of it is cured. Thus, there is a potential for direct inter- and intraspecific competition for high quality forage resources if plantain's abundance in the sward should be reduced through plant succession or overutilization.

CHAPTER XIV

HABITAT SUITABILITY INDICES FOR TULE ELK AND BLACK-TAILED DEER

Habitat Suitability Index (HSI) models synthesize information on the capability of habitats to support species within select geographical boundaries. An HSI model may be viewed as a hypothesis of species-habitat relationships expressed as an index ranging between 0.0 (unsuitable habitat) and 1.0 (optimum habitat) (Fish and Wildlife Service 1981). HSI models were developed for both tule elk and black-tailed deer at Tomales Point.

METHODS

The suitability of select physical and biological attributes of the coastal prairie-coastal scrub mosaic as habitat for tule elk and black-tailed deer was determined by a review of the literature on each species. Information on Roosevelt elk in northern California and Oregon was used to supplement the little information on tule elk, there being no populations of tule elk in the coastal portion of its historic range until recently.

Each 4-ha cell on Tomales Point (Chapter III) was evaluated for all habitat components and given an HSI rating between 0.0 and 1.0 on the basis of models developed separately for each species. Values for individual cells were smoothed using program GOLDEN (Golden Software, P.O. Box 281, Golden, CO 80402) to produce contour lines depicting predicted relative suitability of Tomales Point for each species.

The HSI model for black-tailed deer was tested against actual habitat use as measured by pellet group distribution. Cells sampled for pellet groups to census black-tailed deer (Chapter XI) were grouped by the HSI value assigned as above. The few cells in the highest and lowest HSI rankings were pooled with the next lower and higher HSI classes respectively, leaving three HSI classes (A = 0.4-0.5; B = 0.6; C = 0.7-0.8). Differences in mean density and distribution of pellet groups by HSI classes were examined with program PELANAL (Eberhardt and White 1980) for each of four sample periods.

RESULTS

Tule Elk

<u>Model Objectives</u>--The objective is to produce an estimate of year-round habitat suitability for resident tule elk on Tomales Point, Point Reyes National Seashore, Marin Co. that ranks habitat variables in a manner similar to the way a species authority would approach the problem (Fish and Wildlife Service 1981). It may be applicable to other tule elk populations in the coastal prairie-coastal scrub mosaic should they be established.

The minimum habitat area required to support a band of tule elk is assumed to be 500 ha, the home range of tule elk in the Diablo Range (Phillips 1985). This estimate is somewhat higher than measures of home range of the elk in this study (Chapter IX). A larger area was selected to reflect the expected pattern for a tule elk herd larger than existed during the period of this study.

<u>Model Variables</u>--The model considers nutrients and cover as tule elk life requisites. The quality of these requisites in the coastal prairie-coastal scrub mosaic is

used to calculate an overall HSI. This cover type provides both nutrients and cover (Fig. 39). Cover suitability is derived from aspect, vegetative distribution, shrub density and height, and the presence or absence of gullies. Nutrient suitability is related to the availability of preferred forage plants, soil quality, and the availability of free water.

It is assumed that the limited size of Tomales Point relative to tule elk home range assures satisfactory interspersion of life requisites. Some variables such as free water are ranked higher owing to their proximity, but none are ranked lower because of distance.

Model Structure--Habitat categories for each variable are assigned to one of four classes with a suitability index value assigned to each class (Fig. 40). The suitability of the variables measured is expressed with suitability index values (Fig. 41) derived from general statements in the literature. No variable was rated at the optimum of 1.0 as the general suitability of Tomales Point for tule elk is considered only fair (Chapter I). Existing conditions in each 4-ha cell on Tomales Point were scored

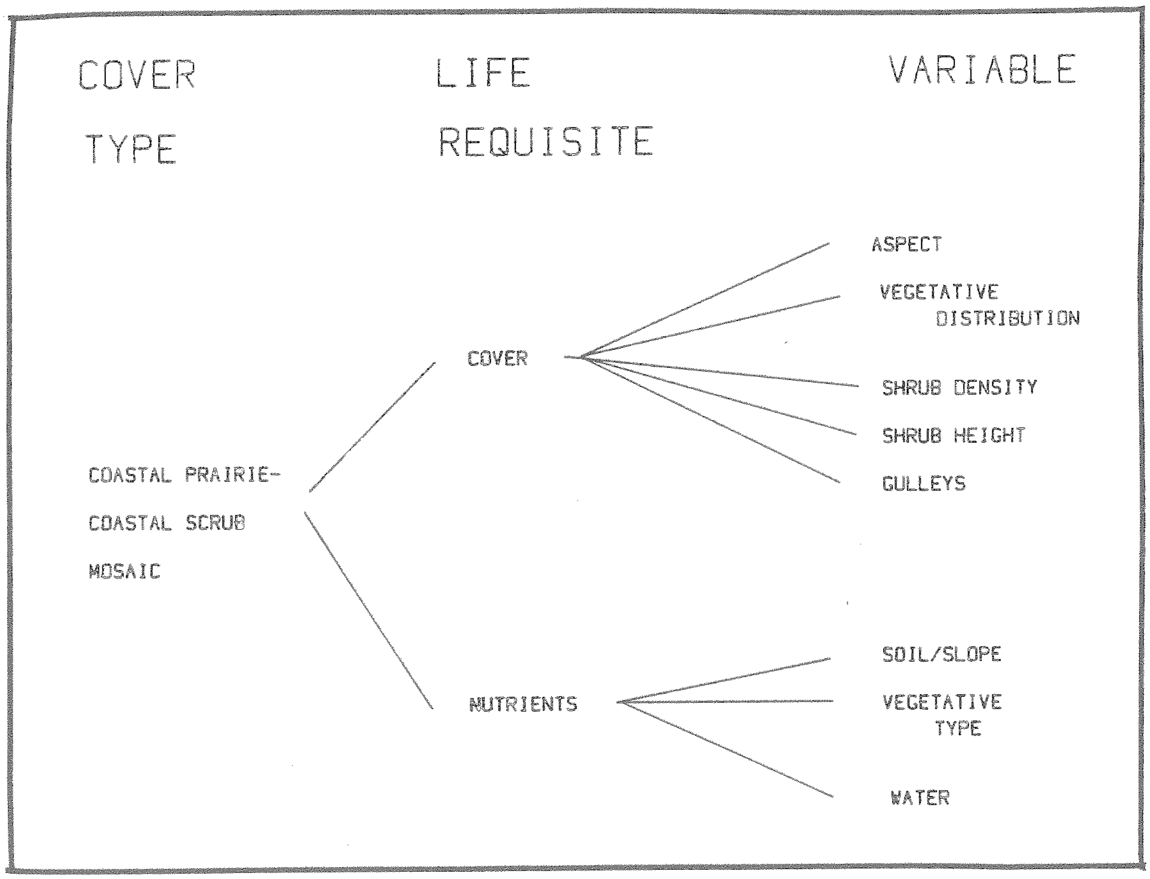

Figure 39. Tree diagram of HSI variables for tule elk and black-tailed deer.

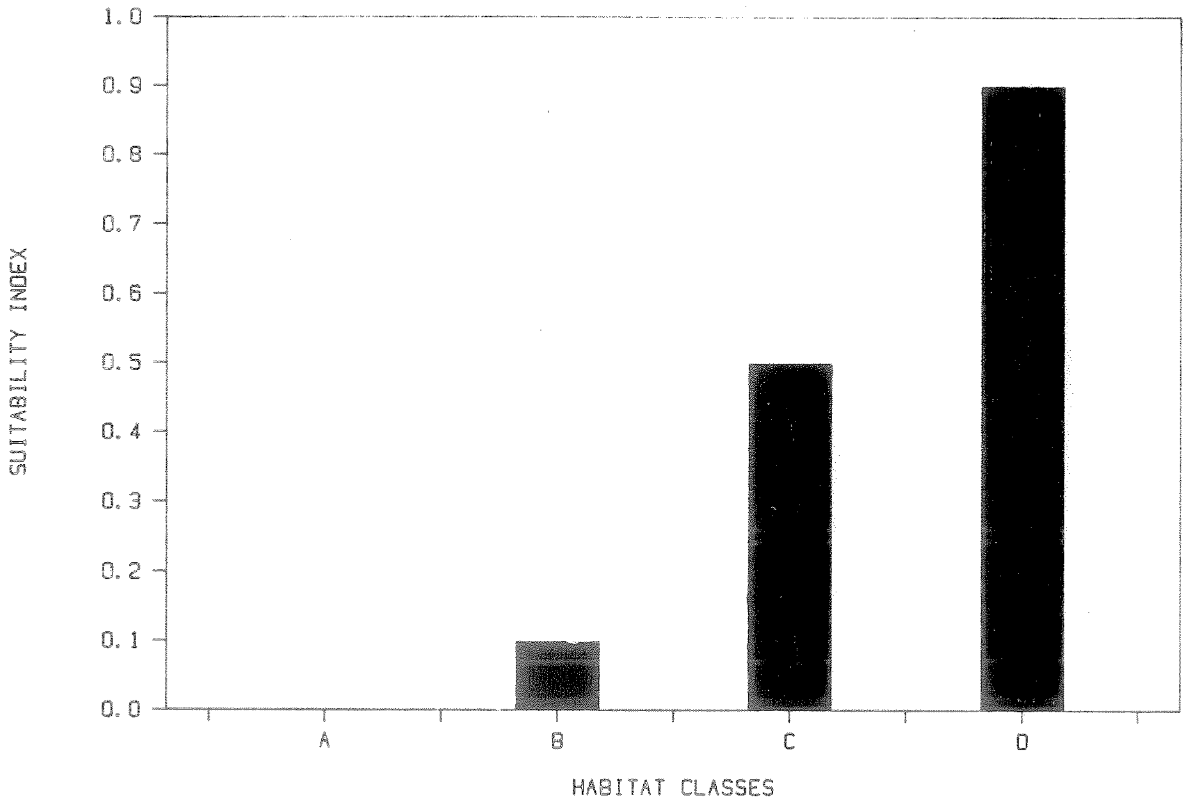

Figure 40. Habitat classes and associated suitability indices used in rating habitat variables in the tule elk and black-tailed deer models.

V_1: ASPECT

B) west, east

C) flat, south, valley

D) knoll, north

V_2: SOIL/SLOPE

B) rocky outcrops, granitic cliffs

C) Sirdrak sand 15-50% slope,
Kehoe coarse loam 15-50% slope,
aquatic tidelands

D) Sirdrak sand 2-15% slope,
Kehoe coarse loam 2-15% slope,
Sheridan coarse loam 9-30% slope

V_3: VEGETATIVE DISTRIBUTION

A) barren

B) enclosed scrub, scrub edge,

C) grass edge

D) enclosed grass

Figure 41. Suitability index values for variables in the tule elk habitat suitability model.

V_4: VEGETATIVE TYPE

A) barren, thick scrub

C) baccharis grassland

D) lupine grassland, open grassland

V_5: SHRUB DENSITY

A) thick

C) medium

D) open, non

V_6: SHRUB HEIGHT

A) 2 m

C) 0.5 - 1 m

D) 0, 0.1 < 0.5 m

V_7: GULLIES

C) present

D) absent

V_8: FREE WATER

C) absent, spring, stream

D) pond

Figure 41. Continued.

for each variable (Fig. 42).

The relationship between variables is considered compensatory (Fish and Wildlife Service 1981). Hence, for each 4-ha cell, they are combined to produce an arithmetic mean HSI value by the formula:

$$HSI = (2(V_1) + 2(V_2) + 3(V_3) + 3(V_4) + 3(V_5) + (V_6) + 2(V_7) + 2(V_8))/18$$

Smoothed cell values show the south central portion of Tomales Point to be the most suitable for tule elk (Fig. 43). This is the area most used by the current elk herd (Chapter IX).

Black-tailed Deer

Model Objectives--The objective is to produce an estimate of year-round habitat suitability that ranks habitat variables for resident black-tailed deer on Tomales Point, Point Reyes National Seashore, Marin Co. in a manner similar to a species authority (Fish and Wildlife Service 1981). It may be applicable to other black-tailed deer populations in the coastal scrub-coastal prairie mosaic.

TOMALES POINT GIS-ELK HABITAT VARIABLE 1: ASPECT

TOMALES POINT GIS-ELK HABITAT VARIABLE 2: SOIL/SLOPE

Figure 42. Suitability index scores for variables in the tule elk habitat suitability model for Tomales Point.

TOMALES POINT GIS-ELK HABITAT VARIABLE 3: VEGETATIVE DISTRIBUTION

0 = UNSUITABLE
1 = MARGINAL
5 = SUITABLE
9 = OPTIMAL

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* * * *
* 9 9 * * *
* 0 9 9 9 * *
* * 9 9 9 9 * *
  * 9 9 9 9 9 * *
  * * 9 9 9 5 5 *
    * 9 9 9 5 1 * *
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      * * 9 5 5 5 1 * *
        * 9 9 9 5 1 1 * *
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          * * 9 9 9 9 5 1 * * *
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                              * * 9 5 1 5 5 5 5 1 1 5 1 1 1 1 1 0 *
                                * * * 0 5 1 5 1 1 1 5 1 1 1 5 1 * *
                                    * * 5 5 1 1 1 1 * 5 5 * * * *
                                      * * 5 5 5 1 * * * * *
                                        * * * * * *
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TOMALES POINT GIS-ELK HABITAT VARIABLE 4: VEGETATIVE TYPE

0 = UNSUITABLE
1 = MARGINAL
5 = SUITABLE
9 = OPTIMAL

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* * * *
* 9 9 * * *
* 0 9 9 9 * *
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  * 9 9 9 9 9 * *
  * * 9 9 9 9 9 *
    * 9 9 9 9 0 * *
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                                    * * 9 5 0 0 0 0 * 5 5 * * * *
                                      * * 9 5 5 0 * * * * *
                                        * * * * * *
```

Figure 42. Continued.

TOMALES POINT GIS-ELK HABITAT VARIABLE 5: BRUSH DENSITY

TOMALES POINT GIS-ELK HABITAT VARIABLE 6: BRUSH HEIGHT

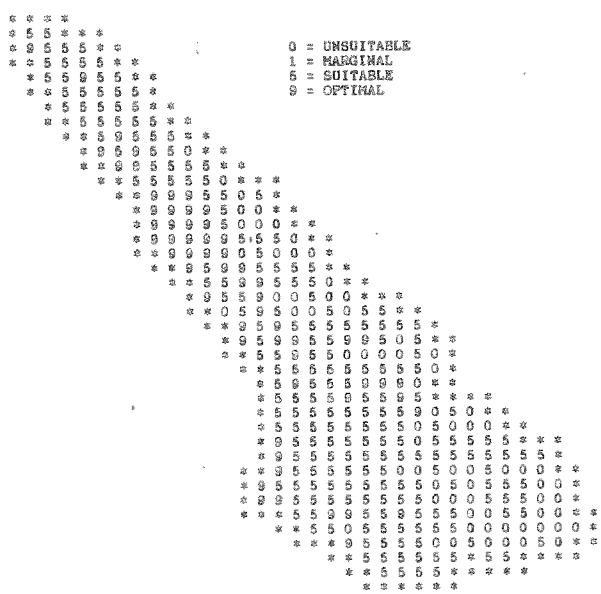

Figure 42. Continued.

TOMALES POINT GIS-ELK HABITAT VARIABLE 7: GULLEYS

TOMALES POINT GIS-ELK HABITAT VARIABLE 8: FREE WATER

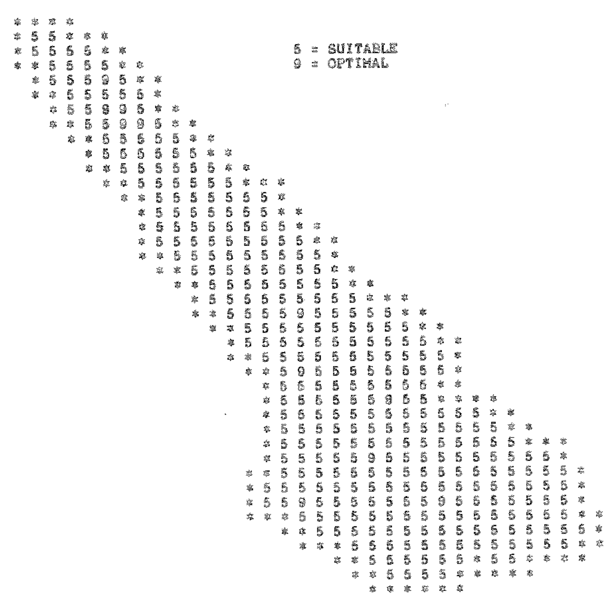

Figure 42. Continued.

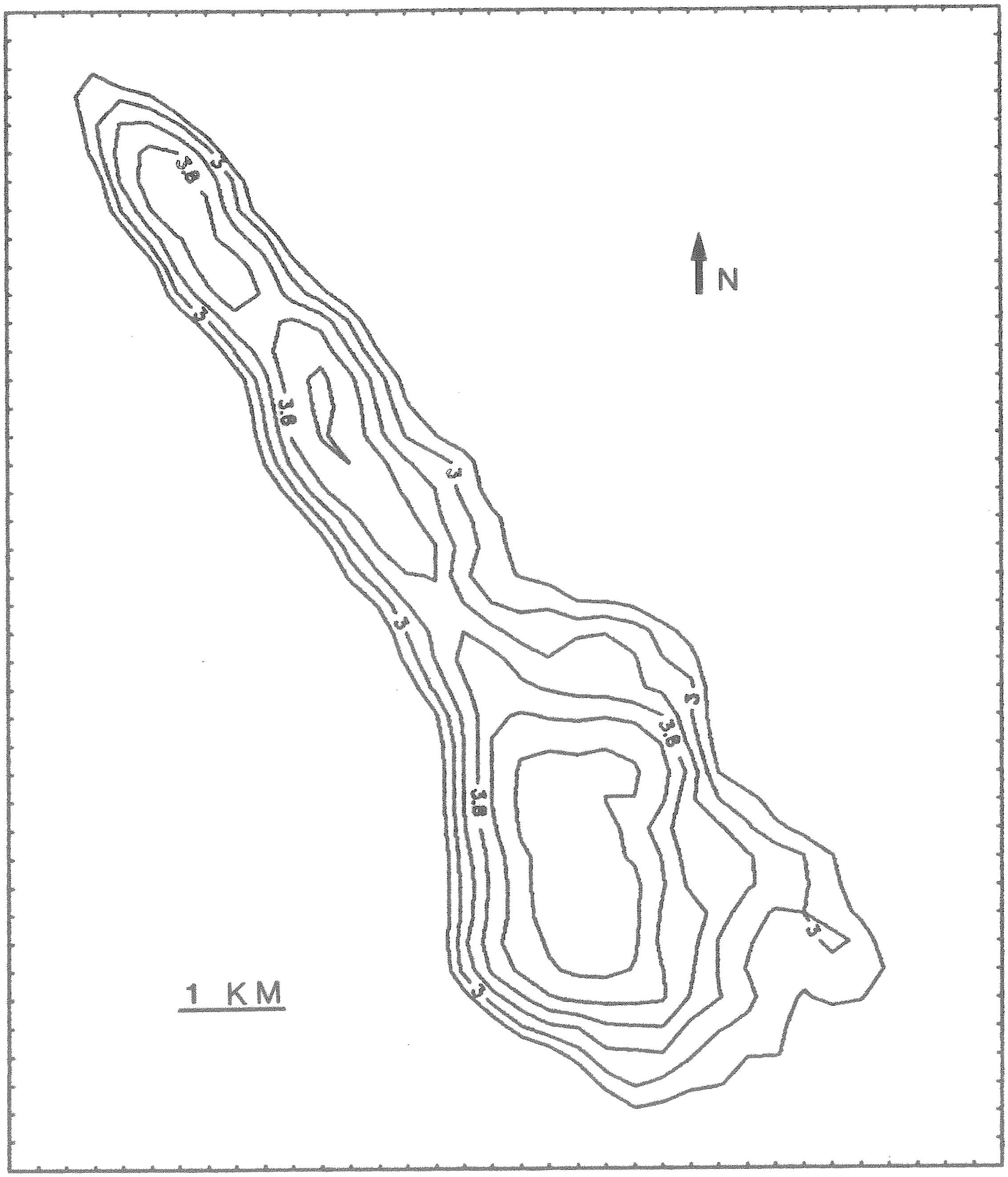

Figure 43. Smoothed habitat suitability index scores for tule elk on Tomales Point.

The minimum habitat area required to support an individual black-tailed deer is a home range of approximately 60 ha (Harestad and Bunnell 1979). Maintenance of a viable population of deer would require an area considerably larger.

Model Variables--The model considers nutrients and cover as deer life requisites. The quality of these requisites in the coastal prairie-coastal scrub cover mosaic is used to calculate an overall HSI. This cover type provides both nutrients and cover (Fig. 39). Cover suitability is derived from aspect, vegetative distribution, shrub density and height, and the presence or absence of gullies. Nutrient suitability is related to the availability of preferred forage plants, soil quality, and the availability of free water.

Interspersion of life requisites is assumed not to be a problem for black-tailed deer. Some variables such as free water are ranked higher owing to their proximity, but none are ranked lower because of distance.

Model Structure--The suitability of the variables measured is depicted by suitability index graphs (Fig. 44) derived from general statements in the literature. No

V_1: ASPECT

B) knoll, north

C) flat, west

D) south, east, valley

V_2: SOIL/SLOPE

B) rocky outcrops, granitic cliffs

C) Sirdrak sand 15-50% slope,
Kehoe coarse loam 15-50% slope,
aquatic tidelands

D) Sirdrak sand 2-15% slope,
Kehoe coarse loam 2-15% slope,
Sheridan coarse loam 9-30% slope

V_3: VEGETATIVE DISTRIBUTION

A) barren

B) enclosed scrub

C) enclosed grass

D) scrub edge, grass edge

Figure 44. Suitability index values for variables in the black-tailed deer habitat suitability model for Tomales Point.

V_4: VEGETATIVE TYPE

A) barren

C) baccharis grassland, thick scrub
lupine grassland, open grassland

V_5: SHRUB DENSITY

B) none

C) thick

D) medium, open

V_6: SHRUB HEIGHT

C) 0, 2 m, 0.1 < 0.5 m

D) 0.5 - 1 m

V_7: GULLIES

C) absent

D) present

V_8: FREE WATER

C) absent

D) spring, stream, pond

Figure 44. Continued.

variable was rated at the optimum of 1.0 as the general suitability of Tomales Point for black-tailed deer is considered only fair (Chapter I). Existing conditions in every 4-ha cell on Tomales Point were scored for each variable (Fig. 45).

The relationship between variables is considered compensatory (Fish and Wildlife Service 1981). Hence, for each 4-ha cell, the variables are combined to produce an arithmetic mean HSI value by the formula:

$$HSI = (3(V_1) + 2(V_2) + 3(V_3) + V_4 + 3(V_5) + 3(V_6) + 3(V_7) + V_8)/19 \qquad (19)$$

Smoothed cell values show a considerable portion of Tomales Point to be suitable for black-tailed deer (Fig. 46). Analysis by program PELANAL revealed no detectable differences in mean density of pellet groups between HSI rankings in any of the four sample periods (Table 42).

DISCUSSION

The large area with a high, smoothed habitat suitability index for tule elk toward the southern end of Tomales Point (Fig. 43) approximates the elks' home range

TOMALES POINT GIS-DEER HABITAT VARIABLE 1: ASPECT

TOMALES POINT GIS-DEER HABITAT VARIABLE 2: SOIL/SLOPE

Figure 45. Suitability index scores for variables in the black-tailed deer habitat suitability model for Tomales Point.

TOMALES POINT GIS-DEER HABITAT VARIABLE 3: VEGETATIVE DISTRIBUTION

TOMALES POINT GIS-DEER HABITAT VARIABLE 4: VEGETATIVE TYPE

Figure 45. Continued.

TOMALES POINT GIS-DEER HABITAT VARIABLE 5: BRUSH DENSITY

TOMALES POINT GIS-DEER HABITAT VARIABLE 6: BRUSH HEIGHT

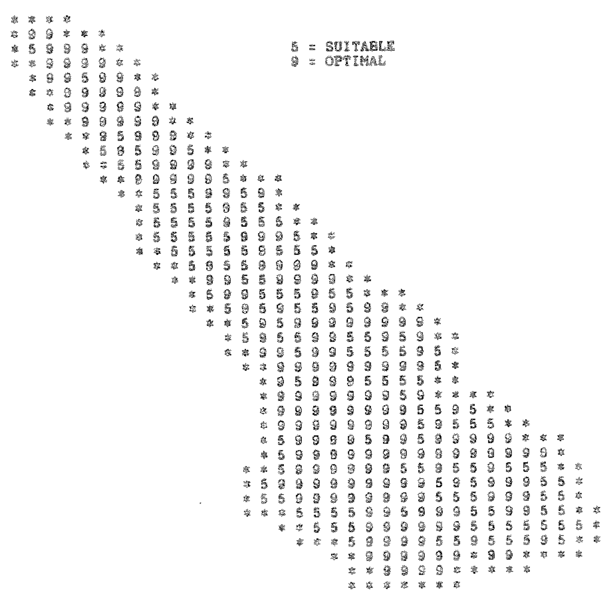

Figure 45. Continued.

TOMALES POINT GIS-DEER HABITAT VARIABLE 7: GULLEYS

TOMALES POINT GIS-DEER HABITAT VARIABLE 8: FREE WATER

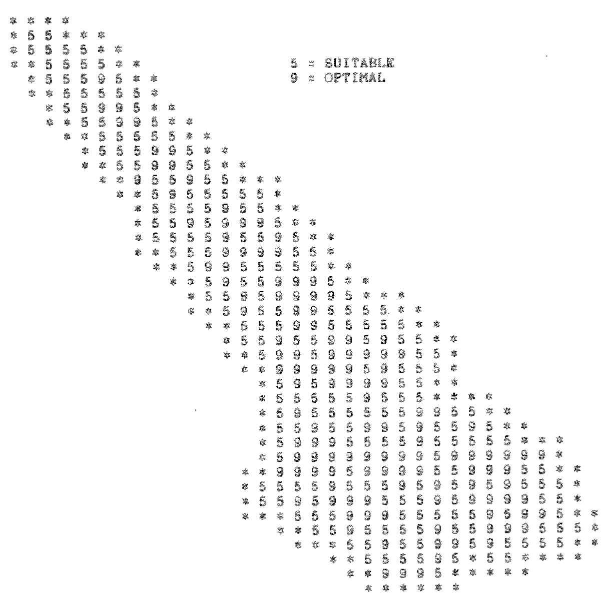

Figure 45. Continued.

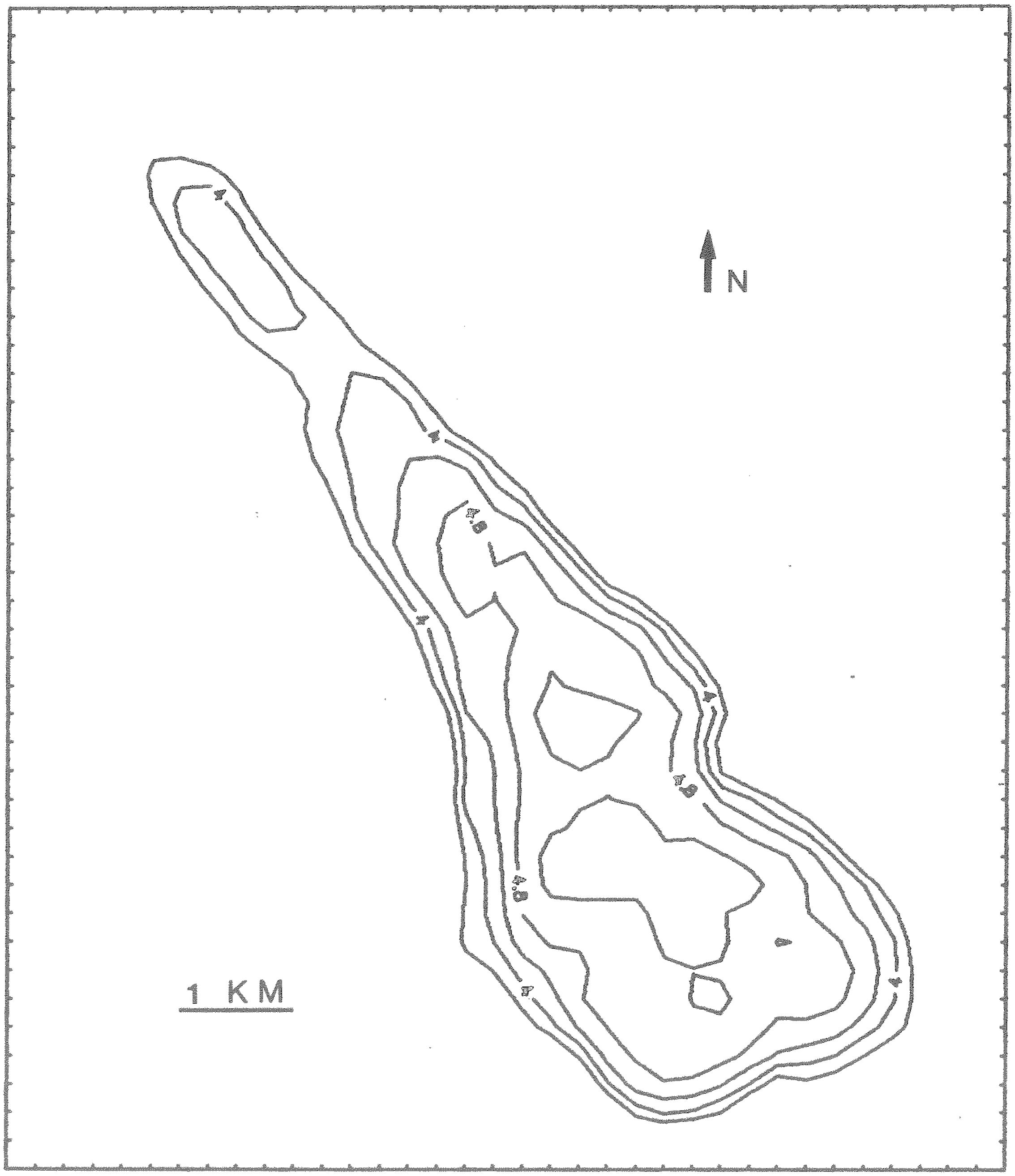

Figure 46. Smoothed habitat suitability index scores for black-tailed deer habitat suitability on Tomales Point.

Table 42. Mean number of pellet-groups deposited per day in 200 x 1.5 m plots in each of three HSI rankings for four sample periods. All values are $x10^{-2}$.

Sample Period	HSI Ranking					
	HSI 5		HSI 6		HSI 7	
	x	SE	x	SE	x	SE
February 1981	5.4	0.8	8.1	0.6	9.9	0.9
April 1981	5.7	0.5	8.5	0.6	4.4	0.4
July 1981	16.5	1.2	7.7	0.5	14.7	0.8
September 1981	8.2	0.9	8.5	0.8	22.4	1.2

for 1978 (Ray 1981) and 1979 through 1981 (Chapter IX). Casual observations from 1982-1985 suggest elk have continued to use the southern area of high HSI while simultaneously utilizing the area at the north end of the Point with a high HSI rating. No sightings have been made of elk between these two areas.

The smoothed habitat suitability model for black-tailed deer (Fig. 49) shows overall higher HSI rankings for deer over a larger area than for elk (Fig. 43). Lack of agreement between the predicted HSI values and pellet-group counts should not lead to rejection of the model. Pellet-group distribution may not be a good measure of use when compared to other measures of habitat use such as telemetry data. Further refinement and testing of the initial model may produce more satisfactory results.

Factors that can confound development of accurate habitat suitability models include lack of accurate habitat data and accurate weighting of the importance of habitat requisites (Laymon and Barrett 1986), as well as use of a grid size comparable to the resolution of habitat components by the target species (Laymon and Reid 1986). Tests of HSI models have shown models to be capable of predicting the presence of target species but not their

density (Marcot et al. 1983). Greater accuracy in predicting differences in species density may be achieved by increased sample intensity and sampling over a greater length of time (Marcot et al. 1983). Models of ungulate-range relationships may be improved by continuing refinement and testing (Allen et al. 1984). Continued development of this model is beyond the scope of this report. However, such a model may be useful in assessing the importance of successional shifts in the vegetation of Tomales Point to elk and deer.

CONCLUSIONS

Habitat suitability models for tule elk and black-tailed deer on Tomales Point suggest a range of habitat quality for both species. The home range of tule elk approximates an area of Tomales Point ranked as having a high HSI. There was no agreement between HSI rankings for deer and the frequency of pellet group deposition. However, refinements to the HSI model and greater sample size in testing the model may provide more satisfactory results.

CHAPTER XV

PREDICTED CARRYING CAPACITY

The meaning of the term carrying capacity has periodically been debated (MacNab 1985). As used here, the term refers to 'K' carrying capacity (KCC) of McCullough (1979) where, "The equilibrium reached between herbivores and their food supply represents the maximum sustainable population level." (MacNab 1985:404). At KCC, the "Rate of increase of both plants and herbivores ... is by definition, zero ..." (MacNab 1985:404). Wild herbivore populations managed to produce an optimal sustained yield are held at an artificial equilibrium density, ICC, which is always below KCC (McCullough 1979, MacNab 1985). Similarly, KCC differs from the range management concept of carrying capacity used by range managers, in which stocking rates of livestock are adjusted to ensure a maximum sustained yield of meat (Heady 1975).

Data from this study and elsewhere are synthesized herein to predict the carrying capacity of Tomales Point for tule elk by a livestock equivalency estimate and a vegetation biomass estimate. An estimate of KCC based upon the population's rate of change has the greatest potential for predicting future carrying capacity.

METHODS

Livestock Equivalency Estimate

The average beef cattle stocking rate in animal unit months (AUMs) for the Seashore's pastoral zone was adjusted downward to compensate for the supplements provided to beef cattle. The resulting figure was converted to an equivalent number of elk and applied to the grassland areas of Tomales Point. Expressed mathematically as,

$$\text{carrying capacity} = (B-(SB))\,(C)\,(A), \qquad (20)$$

where B is the beef cattle stocking rate, S is the percent of the beef cattle diet provided by supplements, C is the conversion ratio between elk and AUMs and A is the area of Tomales Point covered by grasslands.

Vegetative Productivity Estimate

An estimate of annual dry matter biomass of herbaceous vegetation available to mammalian herbivores was calculated as:

$$V = (T - n)\,(A) \qquad (21)$$

where V is herbaceous vegetation available (Kg), T is total annual production of herbaceous vegetation (kg/ha), n is the recommended mulch level (kg/ha), and A is the area of

grassland on Tomales Point (ha). Elk carrying capacity was calculated as:

$$\text{Carrying capacity} = \frac{V_e}{(P_e)I_e} \qquad (22)$$

where V_e is the herbaceous vegetation available to elk, P_e is the proportion of the annual elk diet made up of herbaceous vegetation, and I_e is the amount of dry matter ingested by an elk in a year. V_e is calculated as

$$V_e = V - (V_d + V_m) \qquad (23)$$

where V_d and V_m are the amount of herbaceous vegetation consumed by deer and microtine rodents, respectively.

V_d was estimated as:

$$V_d = P_d\ N\ (0.11(W_d)^{0.75}), \qquad (24)$$

where P_d is the proportion of the annual deer diet made up of herbaceous vegetation, N is the size of deer population on Tomales Point, and W_d is the average live weight of a deer calculated by Elliott (1982:126) as,

w = (male wgt) (males:100 females) + (female wgt) (100 females) + (young wgt) (young:100 females) / (males:100 females) + (100 females) + (fawns:100 females) (25)

and $0.11(W_d)^{0.75}$ is the ratio of daily dry matter forage consumption to deer live weight (Van Dyne et al. 1980). V_m was obtained from published data (Batzli

1969; Batzli and Pitelka 1970).

I_e is calculated as:

$$I_e = R(W_e) \qquad (26)$$

where R is the ratio of dry matter consumption per kilogram of live weight and W_e is the average weight of a tule elk calculated as above for deer.

RESULTS

Livestock Equivalency Estimate

Values substituted into formula (20) are as follows: the average beef cattle stocking rate (B) is 0.33 AUM/ha (Elliott 1982); the average annual dietary supplement rate (S) is 5 percent (S. Phalen, pers. comm.); the conversion ratio for AUM's to elk (C) is 1.5 elk/AUM (Heady 1975); and the area of grasslands on Tomales Point is 675 ha (Chapter III). These values yield an estimated carrying capacity of 315 elk.

Vegetative Productivity Estimate

Values substituted into equation (21) are as follows: 1) an annual herbaceous productivity (T) of 3,000 kg/ha,

taken as a reasonable approximation of annual herbaceous productivity (Chapter III); 2) mulch levels (n) of 1,685 kg/ha as recommended for the soil type and slope levels most common on Tomales Point (Sugnet and Bartolome 1983); and 3) the area (A) of grasslands on Tomales Point is 675 ha (Chapter III). These values yield an available forage biomass (V) of 887,625 kg.

The amount of herbaceous vegetation consumed by deer (V_d) was calculated assuming: 1) the proportion of the annual deer diet consisting of herbaceous vegetation (P_d) is (0.8 x 0.75) or herbaceous vegetation makes up 80 percent of the diet for 75 percent of the year (Chapter XIII); 2) the number of deer on Tomales Point (N) was taken as 300, the highest estimate of population size obtained by line transect censuses in November 1980 (Chapter X); 3) the ratios of males:100 females:fawns of the November 1980 census (Chapter X) were used in calculating mean body weight; 4) values for sex and age-specific body weight were obtained from black-tailed deer in the Seashore's pastoral zone (Elliott 1982:130). Average body weight (W_d) was calculated as 35.1 kg. Using this value an estimated 103,500 kg herbaceous vegetation are consumed annually by deer.

The amount of herbaceous vegetation consumed by microtine rodents (V_m was calculated as 675,000 kg assuming: 1) the long-term average density of voles on Tomales Point is similar to long-term densities of approximately 25/ha reported for Sea Ranch, Sonoma Co. (Krohne 1982); and 2) at this density voles remove approximately 1,000 kg/ha as reported for a coastal prairie in Contra Costa Co. (Batzli 1969, Batzli and Pitelka 1970).

Substituting values for V_d and V_m into equation 23 yields an estimate for V_e of 109,125 kg. The amount of herbaceous vegetation required per elk was calculated from equation 26 as 1,280 kg assuming: 1) the average weight for a tule elk is 250 kg and 185 for an adult male and female, respectively (McCullough 1969), and the average weight of a calf is assumed to be slightly less than half the weight of an adult female or 90 kg; and 2) the ratio of males: 100 females: calves was approximated as 40:100:50. The proportion of the elk diet consisting of herbaceous vegetation (P_e) was taken as 1-(0.2)(0.25) or 0.95 where 0.2 is the proportion of the elk diet consisting of non-herbaceous vegetation for 3 months (0.25 year) (Chapter XIII). An estimated elk carrying capacity of 90 elk is obtained by entering the above values into equation 22.

DISCUSSION

The livestock equivalency and vegetative productivity estimates of 315 and 90 elk respectively probably represent the maximum KCC and minimum ICC for elk on Tomales Point. At densities of 0.31 elk/ha suggested by the livestock equivalency estimate, elk would utilize 403,200 kg of dry matter each year, or approximately 20 percent of the estimated total herbaceous vegetation production by grasslands, reducing the dry matter biomass available to deer and microtine rodents. Competition for forage between elk and deer normally favors elk (Cliff 1939, Flook 1964). Also, heavy range use by elk, deer and microtine rodents will result in mulch levels below those recommended for maximum sustained primary production. There is some question as to whether conditions on Tomales Point will support population growth to such high levels; although localized densities of red deer in Scotland have been reported as high as 0.4/ha (Ratcliffe 1984).

The estimate of 90 elk as a carrying capacity for Tomales Point based upon vegetative productivity also requires careful scrutiny. The estimate is conservative in that it assumes: 1) no herbaceous vegetation is available in the thick scrub type; and 2) there is no advantage to

elk over deer and microtine rodent competitors for forage. Some herbaceous vegetation is available in the thick scrub type. Also, as noted above, past studies suggest elk are capable of out-competing deer for forage resources (Cliff 1939, Flook 1964). Thus, an elk population numbering 90 individuals may approximate ICC.

Other processes may be expected to reduce carrying capacity: 1) any increase in herbaceous production may be reversed if coyote bush continues to invade open grassland areas of Tomales Point as documented from 1980 through 1985 (Chapter III); and 2) the important forage species English plantain (Chapter XIII) is a plant of disturbed areas and the ability of Tomales Point to support both elk and deer may be reduced if plantain becomes less abundant through succession. These considerations could balance each other out and result in a long-term ICC of 90 elk.

Factors other than the quantity of available forage may influence the KCC of elk on Tomales Point. Forage quality, disease and parasites may play vital roles. Elk on Tomales Point exhibited symptoms of copper deficiency (Chapter V) and paratuberculosis (Chapter VI) while sharing the range with some 400 beef cattle, a stocking rate of approximately 0.38 AUM's/ha or slightly above the mean beef cattle

stocking rate for the pastoral zone. While there has been little evidence of either disease since 1981, the potential exists for both to reoccur as elk numbers increase. Also, the filarial worm Elaeophera schneideri is endemic to black-tailed deer on the Point Reyes Peninsula and at least one tabanid fly vector also occurs on the Peninsula (R. Lane, pers. comm.). Elaeophorosis has proved detrimental to elk introduced to New Mexico (Hibler et al. 1969). The possibility of the parasite being transmitted to elk on Tomales Point may be expected to increase as elk numbers increase.

The best measure of KCC is obtained from monitoring the herbivore population's response to range conditions as illustrated for elk at Grizzly Island (Chapter IV). Unfortunately, the negative rate of growth for elk at Point Reyes in 1979 and 1980 precludes use of those years' observations in any calculations. Analysis of observations for 1981 through 1984 suggest a KCC of 140 elk ($Y = 0.503-0.00652x$; $n = 4$; $r = 0.53$). Unfortunately, the confidence band on the regression line is extremely wide. Nevertheless, this may be the best estimate of KCC presently available. A more precise estimate of KCC for elk on Tomales Point can be calculated when more observations are available. The relatively precise

estimate for Grizzly Island was obtained from seven years of observations. The projected KCC of elk of 0.04/ha on the 3,000 ha Grizzly Island (Chapter IV) is approximately one-half the density suggested by the vegetative productivity estimates and one-tenth the livestock equivalency estimate for Tomales Point. However, a considerable portion of Grizzly Island's total area is flooded, and the elk use considerably less than the total 3,000 ha.

CONCLUSIONS

The estimated carrying capacity of 90 elk for Tomales Point derived from partitioning herbaceous vegetative productivity approximates ICC. The livestock equivalency estimate of a KCC of 350 elk is likely too high. A KCC of 140 elk is recommended as the estimate upon which to base management decisions. The precision of this estimate may be improved each year by monitoring the population's rate of change and recalculating the regression.

CHAPTER XVI

MANAGEMENT

MANAGEMENT OBJECTIVES AND POLICIES

State Management Objectives

State legislation enacted in 1971 requires the relocation of tule elk to suitable habitats and the maintenance of all herds and habitats in healthy condition. It also prohibits the taking of tule elk until the statewide population exceeds 2,000 or it is determined by the legislature that suitable areas no longer exist in California to accommodate 2,000 tule elk in healthy condition. The target figure of 2,000 animals is based upon considerations of population genetics and the threat of inbreeding. Long-term maintenance of restricted populations requires a minimum of 1,500 to 2,000 animals (Soule 1980).

Federal-State Agency Cooperation

The United States Department of the Interior classifies the tule elk as a rare species (Tule Elk Interagency Task Force 1979). Congress has required the Secretary of the

Interior to develop a plan for the subspecies restoration and conservation of the subspecies and has directed various federal agencies to make land available to for preservation of tule elk (Tule Elk Interagency Task Force 1979). Ultimate management responsibility is held by the California Fish and Game Commission and Department of Fish and Game. Coordination between state and federal agencies is achieved through the Tule Elk Interagency Task Force with the Bureau of Land Management acting as the lead agency (Tule Elk Interagency Task Force 1979).

National Park Service Management Policy

Management policy for each unit of the National Park Service is guided by the unit's enabling legislation and a set of Service-wide management policies (National Park Service 1978a) that are updated periodically. Each unit's management policy is set forth in a general management plan which designates all lands within that unit into one of four zones: 1) natural; 2) historic; 3) park development; and 4) special use. Wilderness designation has been added to many natural zones.

Service-wide policy for natural zones has been reviewed and summarized recently (Bonnickson and Stone

1982:112-113):

> "...to preserve important natural features, as well as the total natural environment or ecosystem. A natural ecosystem is defined as one that portrays, to the extent feasible, either the same scene that was observed by the first European visitor to the area or the scene that would have existed today, or at some time in the future, if European settlers had not interfered with natural processes.
>
> The difference between the natural state and the managed state of the structural and functional attributes of an ecosystem must be minimized.
>
> An ecosystem that has undergone major European settler-induced changes must be restored, to the extent feasible, to its natural condition.
>
> And all natural processes are to be allowed to operate freely within an ecosystem so long as no species or biotic community is exposed to the possibility of extinction, no unacceptable losses to other resources are anticipated, and human safety is not threatened."

Functionally, natural zones of coastal prairie-coastal scrub mosaic serve as a baseline for comparison of change in "non-natural" areas within the Seashore and throughout the vegetative type's range.

Re-establishment of viable populations of extirpated species such as tule elk to Tomales Point is endorsed by the National Park Service's management policies. Furthermore, the management policies recommend regulation

of such populations to be left to natural processes to the extent possible or where artificial control is necessary, it be done outside Park boundaries (National Park Service 1978a). This policy is being pursued with the Northern Yellowstone elk population (Houston 1982).

A self-sustaining free-ranging ungulate population might be expected to require a wide spectrum of " ... physiographic sites such as bottomlands, upland swales, different slope exposures and interspersions of different vegetation types and plant successional stages" to, " ... provide contingencies for ungulates to obtain food and maintain relatively stable populations in variable and periodically harsh environments." (Cole 1971:420). Direct management is justifiable when these conditions are not met (Cole 1971). "Control of animal populations in the National Parks would appear to us to be an integral part of Park management, best handled by the National Park Service itself." (Leopold et al. 1963). Recommended options for control of populations in order of preference are: 1) natural predation; 2) trapping and transplanting; 3) shooting excess animals as they move outside parks; and 4) control by shooting within parks (Leopold et al. 1963). Public hunting is permitted under the Seashore's enabling legislation and the Wilderness Area designation of Tomales

Point does not preclude hunting. However, public hunts in units of the National Park Service have rarely been successful in controlling ungulate populations (Leopold et al. 1963), a noted exception being control of exotic goats (Capra spp.) and pigs (Sus scrofa) in Hawaii Volcanoes National Park (R. H. Barrett, pers. comm.).

Technical advances now permit reducing the reproductive potential of individual elk. The individual reproductive potential of female elk may be reduced by subdermal implants of ovulating inhibiting hormone capsules or tubal litigation. Both are surgical procedures. Capsules have been used experimentally on white-tailed deer (O. virginianus) in Mammoth Cave National Park (Matschke 1977, 1980), Rocky Mountain goats (Oreamnus americanus) in Olympic National Park (J. J. Aho, pers. comm.) and black-tailed deer at Angel Island State Park (G. S. Fowler, pers. comm.). Implants available to date are projected to be effective for a maximum of 8-9 years although their useful life in free-ranging ungulates may be less (J. J. Aho, pers. comm.). The logistics of restraining and implanting any number of elk on Tomales Point will be time consuming and expensive with little guarantee of success. The procedure was judged unsatisfactory in controlling white-tailed deer in Mammoth Caves National Park because of

the limited efficacy of implants, high cost of chemical registration and expense of capture and recapture (Matschke 1980). Ovariectomy or tubal ligation may be more efficient than subdermal implants as the individual animal need to be restrained only once. Experimental ovariectomy of elk has shown: 1) the surgery is feasible; 2) postoperative survival is high; and 3) the procedure caused abortion in a high proportion of pregnant cows (Greer et al. 1968).

MANAGEMENT AND BIOLOGY

Vegetation-Herbivore Dynamics

The widely accepted model of vegetation-herbivore dynamics summarized by Caughley (1976) suggests an increasing or irrupting herbivore population increasing above the long-term carrying capacity, and then crashing as vegetative resources are utilized beyond a level capable of supporting high herbivore population levels (Fig. 47). Long-term changes in vegetative species composition and soil cover may occur at low levels of vegetation biomass due to heavy utilization. Both vegetation and herbivore biomass go through a series of out of phase oscillations of decreasing magnitude as a new equilibrium is reached. Such a pattern is possible for elk and vegetation on Tomales

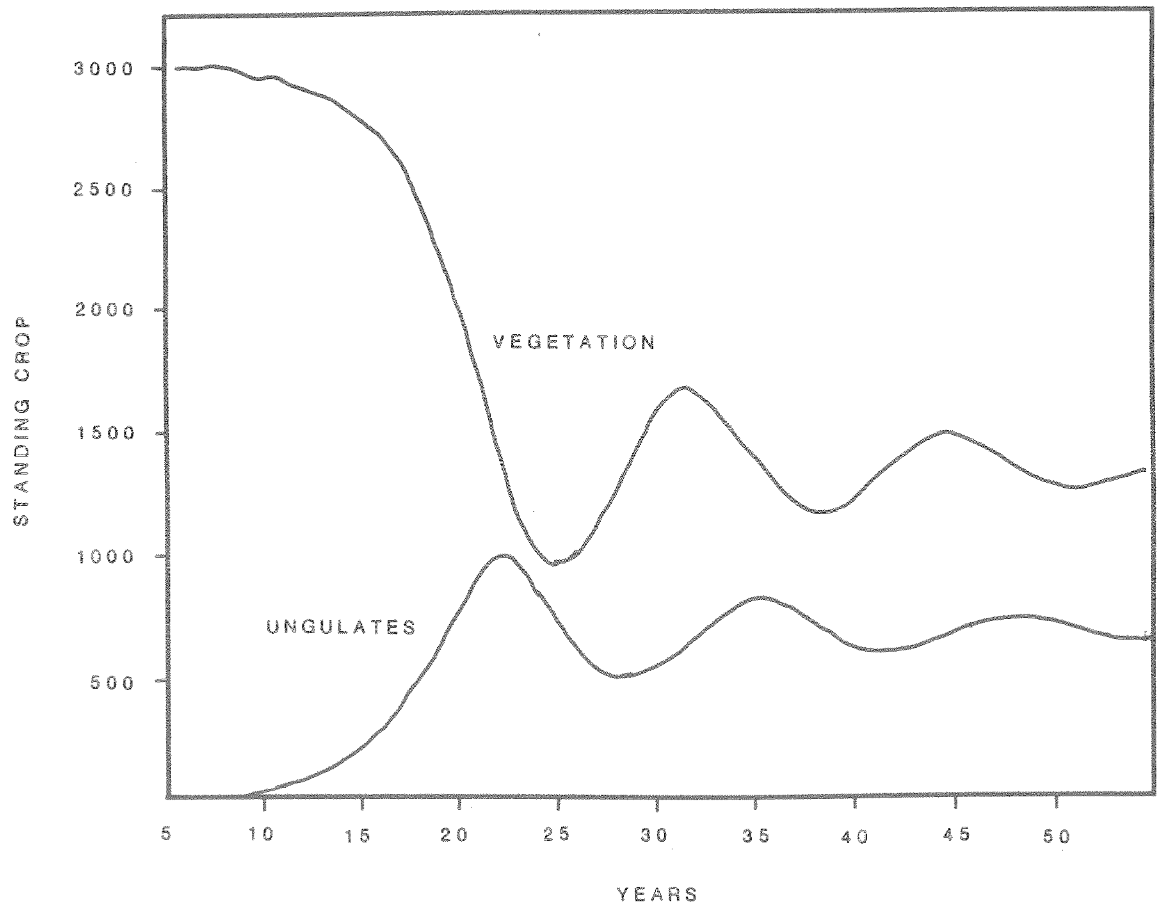

Figure 47. Predicted trends in vegetation and ungulate biomass during and subsequent to an ungulate population eruption (after Caughley 1976:208).

Point given the rapid rate of population growth for elk since 1981 (Chapter IV). Introduction of predators into the vegetation-herbivore model suggests equilibrium may develop sooner and ungulate density may be maintained at a level somewhat below the level dictated by vegetative resources along (Fig. 48) (Caughley 1977).

An alternative possibility is that herbivore intake declines as the vegetation becomes too dense. Consequently, the herbivore population's rate of growth remains low and may decline to zero (Fig. 49) (Caughley 1981). This outcome is also possible for elk-vegetation equilibrium on Tomales Point, with succession to dense shrubs, especially if fire is excluded indefinitely.

Minimal Viable Population

The minimal viable population may be defined as "... the set of specifications concerning the size and structure of the populations comprising a species that is necessary to provide a margin of safety from extinction." (Wilcox 1984:645). The minimal viable population size of a polygamous species such as elk may be calculated from the formula:

$$N_e = 4m\,(1-m)\,N \qquad (27)$$

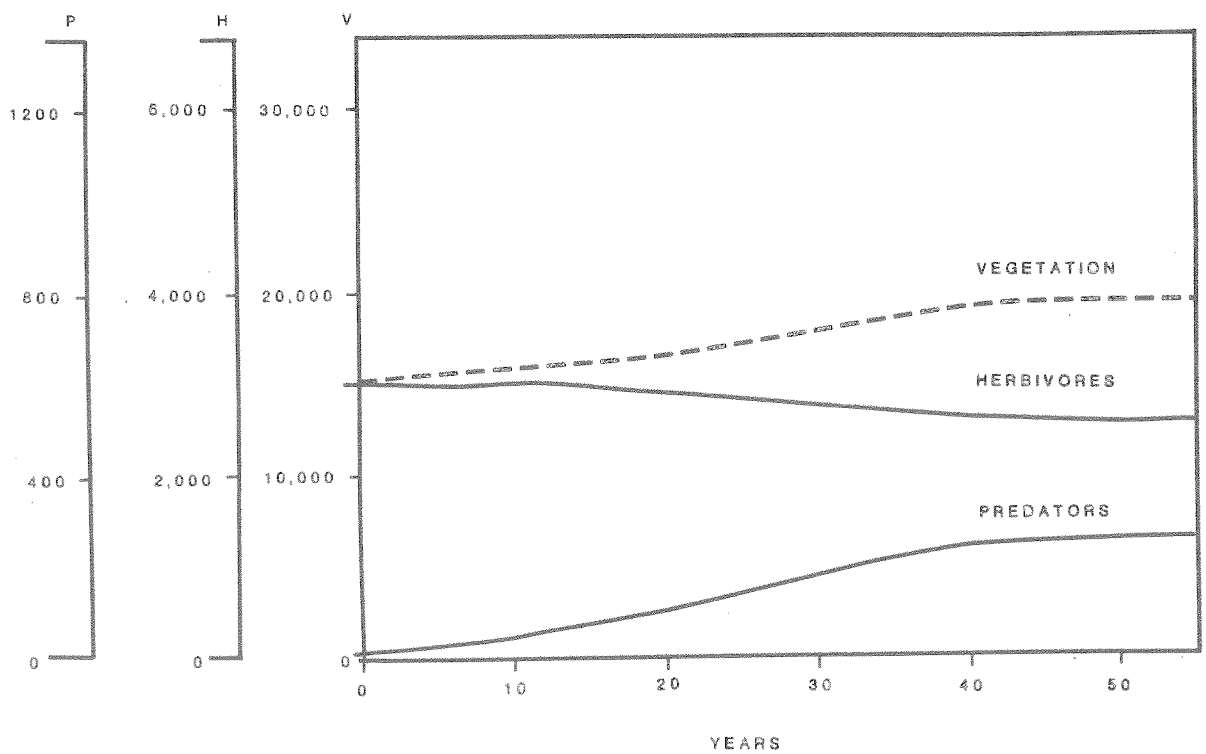

Figure 48. Predicted trends in vegetation and ungulate biomass in the presence of predators (after Caughley 1977:131).

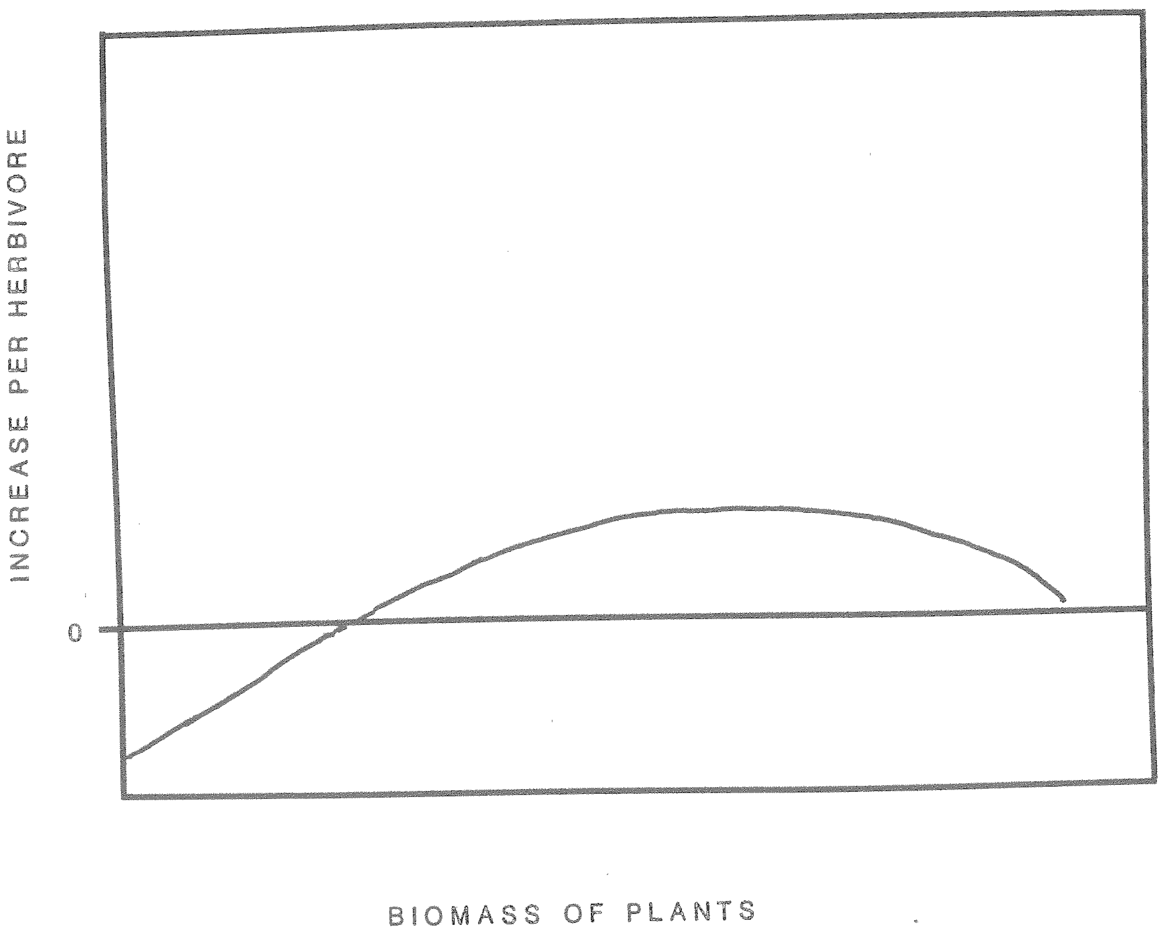

Figure 49. Predicted response of an ungulate population to vegetation biomass when vegetation utilization declines with increasing vegetation density (after Caughley 1981:366).

(LaCava and Hughes 1984:372) where N is total population size, N_e is the effective population size or size of a portion of a population (N) experiencing the same rate of loss of heterozygosity (Franklin 1980) and m is the proportion of males in the population (LaCava and Hughes 1984). Two calculations of minimal viable population size for tule elk at Point Reyes assuming an N_e of 50 for short term management (Franklin 1980) and adult sex ratio of 40 males:100 females and 66 males:100 females yield estimates of minimum population size of 63 and 50, respectively. Both estimates are below the lowest carrying capacity estimate of 90 elk for Tomales Point (Chapter XV). The population size required is reduced as the ratio between sexes approaches unity. This model is somewhat simplistic in that the inbreeding coefficient accumulates linearly over time (Sampson et al. 1985). However, immigration of only one animal once, " ... every 5 years reduces the N_e needed to maintain a population based on genetic considerations to a negligible level." (Sampson et al. 1985:428). In contrast, fluctuations in population size act as population bottlenecks and tend to reduce N_e (Franklin 1980) and these effects may be cumulative (Sampson et al. 1985).

Level of Protection

Nine levels of protection have been identified for species (Schoenwald-Cox 1983). The tule elk population on Tomales Point is best described by a combination of levels two, three, and four. Level two is appropriate in that the tule elk are a recently founded population. Level two protection concerns are: "(1) general diversity will reflect as much of the original diversity of the parent population as possible, (2) the imposition of artificial selection on the population is avoided as much as possible; and (3) the inbreeding coefficient is kept as low as possible ..." (Schoenwald-Cox 1983:435). Level three protection describes an isolated, " ... small population of a characteristically outbreeding species ... with ... the potential dangers of severe bottleneck in population size: inbreeding depression, potentially slow population growth, and secondary loss of rare alleles through genetic drift." (Schoenwald-Cox 1983:435). Populations at level three require veterinary care and diet supplementation. Level four protection describes the situation for tule elk on Tomales Point in that it is, "a small reserve containing a small population of a single managed species in fairly uniform habitat ..." and "...the potential for population crashes resulting from both minor and major catastrophes,

disease, overexploitation of the limited habitat, and inflexibility to the changing environment is high in the span of a few hundred years." (Schoenwald-Cox 1983:436).

MANAGEMENT OPTIONS

There is an inherent conflict in attempting to manage within a Park Service natural zone an ungulate population existing under unnatural conditions, i.e., restricted by fencing to a small area without any opportunity to disperse. The management options set forth attempt to recognize this conflict. Three scenarios of alternate management actions and likely outcomes are discussed to illustrate the wide spectrum of options available. Other management considerations such as protection of rare and endangered species of plants may require some modification to these alternatives. However, the threatened status of the tule elk must also be considered. Any management action should be considered experimental (Sinclair 1979, Houston 1982). "This means that hypothesis to be tested, procedures to be used, and criteria to reject or reformulate hypotheses should be stated clearly in advance. The information obtained from management programs should be reviewed frequently for consistency with the hypothesis being tested." (Houston 1982:197).

The option of relocating tule elk from Point Reyes to other release sites has been precluded by the diagnosis of paratuberculosis in the elk herd at Point Reyes (Chapter VI, Jessup et al. 1981). The disease is both difficult to diagnose and highly contagious to domestic stock and wild ungulates. Similarly, artificial feeding is of questionable value in maintaining a wild ungulate population and is discounted as a management option.

Option I: No Action

The responsible agencies may elect to take no further management actions. One possible outcome is that vegetation may become so dense that it will be of little use to elk. A more commonly predicted outcome is that elk will build up to high numbers and then crash before building up again to begin to oscillate around an equilibrium point (Fig. 47). At equilibrium elk numbers are limited by the vegetative resources and overutilization of vegetation and die-offs may be expected during droughts (Chapter II). At high densities the probability of transmission of paratuberculosis and eleaophorosis is increased, as is the likelihood of nutritional stress leading to copper deficiency. Each oscillation acts as a population bottleneck and in the absence of additional

reintroductions of elk from other sites, there will be a reduction of genetic diversity in the surviving elk. The vegetation standing crop will decline in response to increasing elk numbers (Fig. 47) and long-term changes in botanical species composition and productivity may occur. Invasion of grassland sites will continue or may accelerate with heavy grazing pressure of high elk numbers on herbaceous vegetation and as a result long-term herbaceous production may decline. Also, grazing pressure by elk alone may not reverse successional processes that will reduce the amount of plantain available to elk and deer in the late summer and early fall. Competition between elk and deer for limited forage resources, particularly plantain, may be detrimental to deer and lead to a decline in their density.

Option II: Manage Only the Elk Population

The responsible agencies may elect to implement management by manipulation of the elk population alone. This action will have no effect if the vegetation becomes sufficiently dense to inhibit utilization by elk and thereby an increase in numbers. Culling or controlled shooting of elk may limit numbers and prevent future oscillations in population numbers. Computer simulations

suggest that reducing the growth of the herbivore population while it is still in its eruptive phase may bring both the herbivores and vegetation to a new equilibrium without the initial massive crash in biomass and subsequent oscillations of both (Caughley 1976). Controlled shooting at a rate equal to half the intrinsic rate of population growth while the population is approximately half-way through its growth phase and subsequent reductions in the culling rate determined by vegetative response to reduced herbivore density may achieve an herbivore-vegetation equilibrium in which further shooting is unnecessary. Culling at a lower rate, or not until the population has reached peak density, may create a situation in which a long-term control program is necessary to hold the population in check (Caughley 1976:241).

Any control program that reduces oscillations will favor genetic diversity. Potential inbreeding problems may be further reduced by introducing tule elk from other locations to Tomales Point at least once every five years. Elk densities will remain at or close to the herbivore-vegetation equilibrium and in periods of drought die-offs or nutritionally related problems may occur. Range conditions will continue to change with this option

as succession leads to a decline of plantain and encroachment of coyote bush into areas of open grassland.

Option III: Manage at the System Level

The responsible agencies may elect to manage at the system level by attempting to establish a self-regulating natural system to the extent possible. Establishment of a viable population of coyotes may exert some long-term control on the growth of populations of elk and deer and ultimately reduce their density.

Judicious use of prescribed fire can maintain a mosaic of vegetative communities. Fire in grasslands will maintain areas of grassland in early successional stages with plantain and retard the establishment of coyote bush. Burning in the thick scrub may open up these areas to elk as cover during calving as well as enhance the diversity and productivity of shrub species utilized by deer in this type.

Repair and maintenance of the stock ponds on Tomales Point will encourage a more even distribution of elk utilization of the range, especially in years of less than average rainfall.

System level management is the recommended option. In addition, individuals from other tule elk populations should be introduced to Point Reyes at a minimum of once every four or five years to maintain genetic diversity. The elk population should be culled to maintain the population at slightly below KCC, as determined by monitoring future rate of change in the population. Culling of females to favor a more equal sex ratio among adult elk will reduce the population's reproductive potential while simultaneously increasing the minimum population size.

MANAGEMENT PERSPECTIVE

The actions undertaken to establish tule elk on Tomales Point include: 1) planning; 2) construction of a game-proof fence; 3) lengthy litigation to remove a trespass ranching operation; 4) the actual relocation; 5) acclimatization of elk in a holding pen; 6) research; 7) emergency feeding; and 8) culling of elk with paratuberculosis. The actions represent a laudable cooperative effort by the National Park Service, California Department of Fish and Game and University of California. The introduction of tule elk to Tomales Point may be judged a success, marred only by infection of the herd with paratuberculosis.

However, given the limited size of Tomales Point and an estimated KCC of 140 elk, the population on Tomales Point has no potential to get beyond Schoenwald-Cox's (1983) level four of protection (see level of protection this chapter). Thus, at maximum, the National Park Service will contribute some seven percent of the state legislated goal of 2,000 tule elk. Opportunities to increase the area of Park Service land available to tule elk should be explored, particularly in Golden Gate National Recreation Area and Point Reyes National Seashore. Locales judged unsuitable as release sites in the 1970's may qualify since the Department of Fish and Game has relaxed its requirement that all release sites be fenced. Alternately, considerable monies are being requested and allocated to fence National Park Service lands in Marin County to exclude wild pigs (*Sus scrofa*). Such fences may be modified to keep in tule elk and thereby provide other potential release sites.

Furthermore, Point Reyes National Seashore maintains populations of two exotic deer species. Neither species is endangered in its native habitat. The possibility should be explored of replacing these exotic deer populations with at least an equivalent biomass of tule elk, a threatened native subspecies.

The successful conservation of tule elk will require the continued cooperative management that characterized establishment of tule elk on Tomales Point. Perhaps at some future date the Point Reyes Peninsula will be characterized by descriptions of, " ... a band of elk which must have numbered not less than four hundred head of superb fat animals ... " (Revere 1947:67).

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APPENDIX I. Plant taxa recorded at each vegetation sample location in 1980 and 1981.

CELL=8 YR=80 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	9
LITTER			PLANT LITTER	42
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	2
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	9
FORBS	PERENNIAL	NATIVE	CIRSIUM OCCIDENTALE	1
FORBS	PERENNIAL	NATIVE	ERIGERON GLAUCUS	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	PERENNIAL	NATIVE	OENOTHERA CHEIRANTHIFOLIA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PHACELIA CALIFORNICA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PHACELIA DISTANS	11
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	6
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	40
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	8
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNOWN GRASS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	21
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS LESUEURII	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	20
SHRUBS		NATIVE	LUPINUS ARBOREUS	13

CELL=8 YR=81 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	21
LITTER			PLANT LITTER	38
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	6
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	15
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	51
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	73
FORBS	PERENNIAL	NATIVE	CIRSIUM OCCIDENTALE	1
FORBS	UNKNOWN	UNKNOWN	UNKNOWN PLANT	21
FORBS	UNKNOWN	NATIVE	ERYSIMUM CONCINNUM	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	27
FORBS	PERENNIAL	NATIVE	OENOTHERA CHEIRANTHIFOLIA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PHACELIA DISTANS	37
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	38
FORBS	ANNUAL/BIENNIAL	EXOTIC	SENECIO VULGARIS	17
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	8
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	4
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	41

GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	8

CELL=38 YR=80 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	3
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	5
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	8
FORBS	ANNUAL/BIENNIAL	NATIVE	NAVARRETIA SQUARROSA	3
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	31
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	13
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	33
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	42
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	12
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	97
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	12
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	11
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	75
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	5
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	18
SHRUBS		NATIVE	LUPINUS ARBOREUS	2

CELL=38 YR=81 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	2
LITTER			PLANT LITTER	1
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	6
FORBS	PERENNIAL	NATIVE	LINUM PERENNE	1
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	10
FORBS	ANNUAL/BIENNIAL	NATIVE	NAVARRETIA SQUARROSA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	0
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	43
FORBS	ANNUAL/BIENNIAL	EXOTIC	SHERARDIA ARVENSIS	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	7
FORBS	UNKNOWN	UNKNOWN	VICIA SP	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA SATIVA	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	41
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	47
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	0

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	10
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	31
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	22
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	5
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	56
GRASSES/SEDGES	PERENNIAL	EXOTIC	POA BULBOSA	1
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	3

CELL=50 YR=80 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	2
LITTER			PLANT LITTER	9
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	10
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	PERENNIAL	UNKNOWN	CARDIONEMA RAMOSISSIMA	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	3
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	27
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	21
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	11
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	13
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	23
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	13
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	26
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	25
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	62
SHRUBS		NATIVE	LUPINUS ARBOREUS	7

CELL=50 YR=81 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	4
LITTER			PLANT LITTER	14
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	15
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	17
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	13
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	7

FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	19
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	18
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	3
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	43
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	39
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	TRIFOLIUM GRACILENTUM	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	3
FORBS	PERENNIAL	EXOTIC	RUMEX CRISPUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	22
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	86
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	23
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	22
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	68
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	JUNCUS BUFONIUS	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	14
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	2
SHRUBS		NATIVE	LUPINUS ARBOREUS	3
SHRUBS		NATIVE	RUBUS URSINUS	1

CELL=56 YR=80 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
LITTER			PLANT LITTER	4
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	14
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	2
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HORKELIA CALIFORNICA	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	53
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	25
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	6
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	28
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	26
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	4
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	24
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	11
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	16
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	26

CELL=56 YR=81 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	15
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	12
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	12
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	9
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	1
FORBS	PERENNIAL	UNKNOWN	CARDIONEMA RAMOSISSIMA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	3
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	7
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	9
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	4
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	4
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	6
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	10
FORBS	PERENNIAL	NATIVE	OXALIS PILOSA	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	37
FORBS	ANNUAL/BIENNIAL	EXOTIC	SENECIO VULGARIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	26
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	17
FORBS	UNKNOWN	UNKNOWN	VICIA SP	5
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	13
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	46
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	23
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	17
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	33
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	POA BULBOSA	1
SHRUBS	PERENNIAL	NATIVE	RHAMNUS CALIFORNICA	1

CELL=57 YR=80 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	12
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	12
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	4
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1

FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	51
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	19
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	3
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	9
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	23
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	18
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	9
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	12
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	20
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	70
SHRUBS		NATIVE	LUPINUS ARBOREUS	4
SHRUBS		NATIVE	RHUS DIVERSILOBA	2

CELL=57 YR=81 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	31
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	23
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	40
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	1
FORBS	PERENNIAL	EXOTIC	APIUM GRAVEOLENS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	2
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	17
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	15
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	15
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	24
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	6
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	94
FORBS	PERENNIAL	NATIVE	LATHYRUS JEPSONII	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	7
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	6
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	3
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	0
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	PERENNIAL	NATIVE	STELLARIA JAMESIANA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	17
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	29
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	1
FORBS	PERENNIAL	NATIVE	VICIA AMERICANA	8
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1

FORBS	UNKNOWN	UNKNOWN	UMBELLULARIA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	70
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	42
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	3
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	16
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	62
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNOWN GRASS	7
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	25
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	9
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	42
SHRUBS		NATIVE	LUPINUS ARBOREUS	4
SHRUBS		NATIVE	RUBUS URSINUS	2

CELL=88 YR=80 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	7
LITTER			PLANT LITTER	8
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	5
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	10
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	2
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	33
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	23
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	7
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	22
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	8
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	15
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	18
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	37
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	RHUS DIVERSILOBA	1
SHRUBS		UNKNOWN	RUBUS SPP	3

CELL=88 YR=81 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	4
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	23
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	34
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	75
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	2

FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	15
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	11
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	5
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	97
FORBS	PERENNIAL	NATIVE	LATHYRUS JEPSONII	3
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	4
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PLATYSTEMON CALIFORNICUS	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	3
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	76
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	4
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	25
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	3
FORBS	PERENNIAL	NATIVE	VICIA AMERICANA	2
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	2
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS HALII	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	23
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	66
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	54
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	17
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	50
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	75
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	5
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	58
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	17
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	RUBUS URSINUS	2

CELL=99 YR=80 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	7
LITTER			PLANT LITTER	23
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	5
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	13
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	7
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	6
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	3
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	8
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	10
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	9
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1

SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	4
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	5
SHRUBS		NATIVE	BACCHARIS PILULARIS	32
SHRUBS		NATIVE	MIMULUS AURANTIACUS	4
SHRUBS		NATIVE	RHUS DIVERSILOBA	19
SHRUBS		UNKNOWN	RUBUS SPP	14
SHRUBS		NATIVE	RUBUS PARVIFLORUS	4

CELL=99 YR=81 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	84
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	11
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	19
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	5
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	3
FORBS	PERENNIAL	EXOTIC	ANAPHALLIS MARGARITACEA	16
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	4
FORBS	ANNUAL/BIENNIAL	NATIVE	DAUCUS PUSILLUS	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	24
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	28
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	3
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1
FORBS	PERENNIAL	NATIVE	OXALIS PILOSA	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	PTEROSTEGIA DRYMARIOIDES	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	14
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	24
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	3
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	13
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	45
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	2
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	23
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	5
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	9
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	60
SHRUBS		NATIVE	MIMULUS AURANTIACUS	4

SHRUBS		NATIVE	RHUS DIVERSILOBA	43
SHRUBS		NATIVE	RUBUS URSINUS	11

CELL=100 YR=80 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	22
LITTER			PLANT LITTER	33
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	10
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENIS	3
FORBS	PERENNIAL	EXOTIC	ANAPHALLIS MARGARITACEA	2
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	3
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	2
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	5
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	8
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	2
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	3
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	8
SHRUBS		NATIVE	BACCHARIS PILULARIS	29
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	4
SHRUBS		NATIVE	MIMULUS AURANTIACUS	10
SHRUBS		NATIVE	MYRICA CALIFORNICA	8
SHRUBS		NATIVE	RHUS DIVERSILOBA	24
SHRUBS		NATIVE	RUBUS PARVIFLORUS	7

CELL=100 YR=81 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	22
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	1
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	19
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENIS	24
FORBS	ANNUAL/BIENNIAL	NATIVE	ARTEMISIA DOUGLASII	3
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	29
FORBS	ANNUAL/BIENNIAL	NATIVE	DAUCUS PUSILLUS	2
FORBS	PERENNIAL	NATIVE	ERIOPHYLLUM STAECHADIFOLIUM	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	2
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	60
FORBS		UNKNOWN	UNKNOWN GALIUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	1
FORBS	ANNUAL/BIENNIAL	NATIVE	GNAPHALIUM CALIFORNICUM	4

FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	18
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	6
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	3
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	26
FORBS	ANNUAL/BIENNIAL	NATIVE	PTEROSTEGIA DRYMARIOIDES	3
FORBS	PERENNIAL	NATIVE	SANICULA CRASSICAULIS	2
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	17
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	29
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	5
FORBS	UNKNOWN	UNKNOWN	VICIA SP	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	47
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	10
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	7
GRASSES/SEDGES	UNKNOWN	UNKNOWN	CAREX	8
GRASSES/SEDGES	UNKNOWN	UNKNOWN	CAREX	2
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	37
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	7
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	3
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNOWN GRASS	9
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	15
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	7
SHRUBS		NATIVE	BACCHARIS PILULARIS	65
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	7
SHRUBS		NATIVE	HOLODISCUS DISCOLOR	1
SHRUBS		NATIVE	LONICERA HISPIDULA	9
SHRUBS		NATIVE	MIMULUS AURANTIACUS	19
SHRUBS		NATIVE	OSMARONIA CERASIFORMIS	9
SHRUBS		NATIVE	RHUS DIVERSILOBA	22
SHRUBS		UNKNOWN	RUBUS SPP	4
SHRUBS		NATIVE	RUBUS PARVIFLORUS	1
SHRUBS		NATIVE	RUBUS URSINUS	2

CELL=122 YR=80 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	54
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	3
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	10
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	4
FORBS	PERENNIAL	EXOTIC	ANAPHALLIS MARGARITACEA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	2
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	8
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	21
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	4
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	19

FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	8
FORBS	PERENNIAL	NATIVE	SCROFULARIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	23
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	80
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	2
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	36
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	12
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	22
GRASSES/SEDGES	UNKNOWN	UNKNOWN	JUNCUS SPP	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	39
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	3
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	31
SHRUBS		NATIVE	MYRICA CALIFORNICA	2
SHRUBS		NATIVE	RHUS DIVERSILOBA	21
SHRUBS		UNKNOWN	RUBUS SPP	16
SHRUBS		NATIVE	RUBUS PARVIFLORUS	4
SHRUBS		NATIVE	SAMBUCUS CALLICARPA	2

CELL=122 YR=81 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	62
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	1
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	26
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	8
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	1
FORBS	PERENNIAL	EXOTIC	ANAPHALLIS MARGARITACEA	3
FORBS	PERENNIAL	EXOTIC	APIUM GRAVEOLENS	3
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	4
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	DAUCUS PUSILLUS	2
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	16
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	2
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	25
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	34
FORBS	PERENNIAL	NATIVE	LATHYRUS JEPSONII	3
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	9
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	5
FORBS	ANNUAL/BIENNIAL	NATIVE	PTEROSTEGIA DRYMARIOIDES	6
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	13
FORBS	PERENNIAL	NATIVE	SANICULA CRASSICAULIS	2

FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	24
FORBS	PERENNIAL	NATIVE	SCROFULARIA CALIFORNICA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	2
FORBS	PERENNIAL	NATIVE	STELLARIA JAMESIANA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	5
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	13
FORBS	UNKNOWN	UNKNOWN	VICIA SP	2
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	4
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS HALII	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	38
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	38
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	8
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	70
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	7
GRASSES/SEDGES	PERENNIAL	NATIVE	MELICA GEYERI	2
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	62
SHRUBS		NATIVE	MIMULUS AURANTIACUS	1
SHRUBS		NATIVE	RHUS DIVERSILOBA	53
SHRUBS		NATIVE	RUBUS PARVIFLORUS	5
SHRUBS		NATIVE	RUBUS URSINUS	10
SHRUBS		NATIVE	RUBUS VITIFOLIUS	3

CELL=134 YR=80 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	2
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	3
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	24
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	15
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS EXARATA	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	34
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	2
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	1
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	10
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	25
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	19
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	50
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	3

SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	3
SHRUBS		NATIVE	BACCHARIS PILULARIS	8
SHRUBS		NATIVE	RHUS DIVERSILOBA	1

CELL=134 YR=81 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	5
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7
FORBS	PERENNIAL	UNKNOWN	BRODIAEA CORONARIA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	2
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	28
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO ARABICA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	90
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	26
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	5
FORBS	PERENNIAL	NATIVE	SIDALCEA MALVAEFLORA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	79
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	77
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	6
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	5
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	3
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNOWN GRASS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	18
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	13
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	64
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	23
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	15
SHRUBS		NATIVE	RHUS DIVERSILOBA	2

CELL=141 YR=80 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	15
LITTER			PLANT LITTER	16
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7
FORBS	PERENNIAL	NATIVE	ERIGERON GLAUCUS	2
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	4
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	10
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	27
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	8
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	46
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	52
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	18
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	47
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	5
SHRUBS		NATIVE	BACCHARIS PILULARIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	3

CELL=141 YR=81 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	9
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	9
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	21
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	3
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	2
FORBS	PERENNIAL	NATIVE	ERIGERON GLAUCUS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	8
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	20
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	21
FORBS	ANNUAL/BIENNIAL	NATIVE	LOTUS HUMISTRATUS	2
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	4
FORBS	ANNUAL/BIENNIAL	NATIVE	PLATYSTEMON CALIFORNICUS	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	9

FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	40
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	7
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA SATIVA	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	35
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	43
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	62
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	61
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	50
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	7
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	26
SHRUBS	PERENNIAL	NATIVE	RHAMNUS CALIFORNICA	8
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	2

CELL=142 YR=80 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	7
LITTER			PLANT LITTER	31
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	17
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	8
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	8
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	5
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	4
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	11
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	11
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	6
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	19
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	23
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	3
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	29
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	11
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	12
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	48
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	3
SHRUBS		NATIVE	BACCHARIS PILULARIS	31
SHRUBS		NATIVE	LUPINUS ARBOREUS	1
SHRUBS		NATIVE	MIMULUS AURANTIACUS	2
SHRUBS		NATIVE	MYRICA CALIFORNICA	2
SHRUBS		NATIVE	RHUS DIVERSILOBA	13

SHRUBS		UNKNOWN	RUBUS SPP	14
SHRUBS		NATIVE	RUBUS PARVIFLORUS	17

CELL=142 YR=81 SECTION=NORTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	20
LITTER			PLANT LITTER	28
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	20
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	9
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	11
FORBS	ANNUAL/BIENNIAL	NATIVE	ALCHEMILLA OCCIDENTALIS	2
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	4
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	1
FORBS	UNKNOWN	NATIVE	CARDAMINE OLIGOSPERMA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	EXOTIC	DELPHINIUM DECORUM	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	9
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	9
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	8
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	35
FORBS	ANNUAL/BIENNIAL	NATIVE	HESPEROCNIDE TENELLA	6
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	15
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	2
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	3
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	26
FORBS	ANNUAL/BIENNIAL	NATIVE	NEMOPHILA MENZIESII	1
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	3
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	12
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	6
FORBS	PERENNIAL	NATIVE	SANICULA CRASSICAULIS	3
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	12
FORBS	ANNUAL/BIENNIAL	EXOTIC	SCANDIX PECTEN-VENERIS	2
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	4
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	4
FORBS	PERENNIAL	NATIVE	TELLIMA GRANDIFLORA	1
FORBS	PERENNIAL	NATIVE	URTICA CALIFORNICA	10
FORBS	UNKNOWN	UNKNOWN	VICIA SP	2
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	17
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	27
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	36

GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	33
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	14
SHRUBS		NATIVE	BACCHARIS PILULARIS	32
SHRUBS		NATIVE	MYRICA CALIFORNICA	2
SHRUBS		NATIVE	RHUS DIVERSILOBA	14
SHRUBS		NATIVE	RUBUS PARVIFLORUS	18
SHRUBS		NATIVE	RUBUS URSINUS	7

CELL=143 YR=80 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	9
LITTER			PLANT LITTER	45
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	6
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	21
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	PERENNIAL	EXOTIC	ANAPHALLIS MARGARITACEA	5
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	1
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	6
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	15
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	26
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	4
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	5
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	4
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	3
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	9
FORBS	UNKNOWN	UNKNOWN	VICIA SP	2
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	9
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	8
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	30
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	6
GRASSES/SEDGES	PERENNIAL	EXOTIC	FESTUCA ELATIOR	26
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	41
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	15
SHRUBS		NATIVE	BACCHARIS PILULARIS	36
SHRUBS		NATIVE	RHUS DIVERSILOBA	19
SHRUBS		UNKNOWN	RUBUS SPP	11
SHRUBS		NATIVE	RUBUS PARVIFLORUS	11

CELL=143 YR=81 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	11
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	10
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	28
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	8
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	1
FORBS	PERENNIAL	EXOTIC	ANAPHALLIS MARGARITACEA	9
FORBS	PERENNIAL	EXOTIC	APIUM GRAVEOLENS	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	1
FORBS	PERENNIAL	NATIVE	CIRSIUM OCCIDENTALE	8
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	24
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	1
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	17
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	2
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	49
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	7
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	5
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	7
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	5
FORBS	PERENNIAL	NATIVE	SANICULA CRASSICAULIS	5
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	4
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	18
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	10
FORBS	PERENNIAL	NATIVE	TELLIMA GRANDIFLORA	1
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	1
FORBS	PERENNIAL	NATIVE	URTICA CALIFORNICA	2
FORBS	UNKNOWN	UNKNOWN	VICIA SP	10
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA SATIVA	2
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	2
FORBS	UNKNOWN	UNKNOWN	UMBELLULARIA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	21
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	37
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	12
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	26
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	JUNCUS BUFONIUS	2
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	6
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	POA BULBOSA	2
SHRUBS	PERENNIAL	NATIVE	RHAMNUS CALIFORNICA	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	38
SHRUBS		NATIVE	RHUS DIVERSILOBA	10
SHRUBS		NATIVE	RUBUS PARVIFLORUS	6

SHRUBS		NATIVE	RUBUS URSINUS	22
SHRUBS		NATIVE	SAMBUCUS CALLICARPA	1

CELL=163 YR=80 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	13
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	1
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	19
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	1
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	23
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	4
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS EXARATA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	31
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	65
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	6
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	7
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	65
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	5
SHRUBS		NATIVE	BACCHARIS PILULARIS	17

CELL=163 YR=81 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	2
LITTER			PLANT LITTER	2
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	15
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	2
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	6
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	36
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	69
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	16

FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	5
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	5
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	47
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS BREVIARISTATUSUS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	4
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	15
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	27
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	2
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	8
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	5
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	55
GRASSES/SEDGES	PERENNIAL	EXOTIC	PLANTAGO MAJOR	1
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	69
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	22

CELL=164 YR=80 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	20
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	8
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	2
FORBS	PERENNIAL	NATIVE	ERIGERON GLAUCUS	6
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	2
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	6
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	7
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	21
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	8
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	39
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	8
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	29
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	CYNOSURUS ECHINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	57
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	5
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	29
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	46

SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	5
SHRUBS		NATIVE	BACCHARIS PILULARIS	23
SHRUBS		NATIVE	RHUS DIVERSILOBA	14
SHRUBS		UNKNOWN	RUBUS SPP	2

CELL=164 YR=81 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	9
LITTER			PLANT LITTER	12
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	10
FORBS	PERENNIAL	NATIVE	ACAENA CALIFORNICA	1
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	9
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	14
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	4
FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	6
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	12
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	5
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	18
FORBS	ANNUAL/BIENNIAL	NATIVE	LINANTHUS ANDROSACEUS	4
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	4
FORBS	PERENNIAL	NATIVE	OXALIS PILOSA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	48
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	37
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3
FORBS	PERENNIAL	NATIVE	SIDALCEA MALVAEFLORA	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	TRIFOLIUM PROCUMBENS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	47
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	2
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS BREVIARISTATUSUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	4
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	14
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	5
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	59
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	25
SHRUBS		NATIVE	BACCHARIS PILULARIS	38

SHRUBS		NATIVE	MIMULUS AURANTIACUS	1
SHRUBS		NATIVE	RHUS DIVERSILOBA	10
SHRUBS		NATIVE	RUBUS URSINUS	3

CELL=165 YR=80 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	4
LITTER			PLANT LITTER	21
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	7
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	1
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	4
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	29
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	27
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	CYNOSURUS ECHINATUS	7
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	11
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	40
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	40
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	34
SHRUBS		NATIVE	BACCHARIS PILULARIS	10
SHRUBS		NATIVE	RHUS DIVERSILOBA	14
SHRUBS		UNKNOWN	RUBUS SPP	3
SHRUBS		NATIVE	RUBUS PARVIFLORUS	2

CELL=165 YR=81 SECTION=NORTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	12
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	3
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7
FORBS	PERENNIAL	NATIVE	ACAENA CALIFORNICA	2
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	2
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	4
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	12
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	1

FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	9
FORBS	PERENNIAL	NATIVE	GRINDELIA STRICTA	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	4
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	12
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	9
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	3
FORBS	PERENNIAL	NATIVE	OXALIS PILOSA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	15
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	26
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	4
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	1
FORBS	PERENNIAL	NATIVE	STELLARIA JAMESIANA	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	4
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	2
FORBS	UNKNOWN	UNKNOWN	VICIA SP	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	5
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS BREVIARISTATUSUS	11
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	31
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	11
GRASSES/SEDGES	UNKNOWN	UNKNOWN	CAREX	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	CYNOSURUS ECHINATUS	4
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	13
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	16
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	34
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	33
GRASSES/SEDGES	PERENNIAL	NATIVE	MELICA GEYERI	3
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	27
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	8
SHRUBS		NATIVE	BACCHARIS PILULARIS	23
SHRUBS		NATIVE	RHUS DIVERSILOBA	20
SHRUBS		NATIVE	RUBUS URSINUS	6

CELL=169 YR=80 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	15
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	1
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	4
FORBS	UNKNOWN	UNKNOWN	LOTUS SP	3
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	7
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	14
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	1

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	13
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	8
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	DACTYLIS GLOMERATA	1
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	10
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	1
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	3
SHRUBS		NATIVE	LUPINUS ARBOREUS	1
SHRUBS		NATIVE	RHUS DIVERSILOBA	1
SHRUBS		UNKNOWN	RUBUS SPP	3

CELL=169 YR=81 SECTION=NORTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	19
FORBS	PERENNIAL	NATIVE	ACAENA CALIFORNICA	4
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	9
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	1
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	19
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	10
FORBS	PERENNIAL	NATIVE	LOTUS FORMOSISSIMUS	3
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	PERENNIAL	NATIVE	OENOTHERA OVATA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS FLORIBUNDUS	7
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	29
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	52
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	4
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	6
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	32
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	18
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	23
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	4
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	30
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	POA BULBOSA	4
SHRUBS	PERENNIAL	NATIVE	RHAMNUS CALIFORNICA	3

CELL=183 YR=80 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	11
LITTER			PLANT LITTER	41
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	5
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	6
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	55
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	7
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	10
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	19
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	6
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	27
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	18
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	17
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	11
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	53
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	10
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	77
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	17
SHRUBS		UNKNOWN	RUBUS SPP	6

CELL=183 YR=81 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	11
LITTER			PLANT LITTER	10
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	50
FORBS	ANNUAL/BIENNIAL	NATIVE	ALCHEMILLA OCCIDENTALIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	18
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	13
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	2
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	35
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	3
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	18
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	11
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	88
FORBS	ANNUAL/BIENNIAL	NATIVE	LINANTHUS ANDROSACEUS	4

FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	43
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	27
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	3
FORBS	ANNUAL/BIENNIAL	NATIVE	PLATYSTEMON CALIFORNICUS	29
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	16
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	27
FORBS	PERENNIAL	NATIVE	SANICULA CRASSICAULIS	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	14
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	4
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	70
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	50
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	10
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	45
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	26
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	6
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	10
SHRUBS		NATIVE	BERBERIS PINNATA	15
SHRUBS		NATIVE	LONICERA HISPIDULA	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	17
SHRUBS		NATIVE	RHUS DIVERSILOBA	3
SHRUBS		NATIVE	RUBUS URSINUS	2
SHRUBS		NATIVE	RUBUS VITIFOLIUS	15

CELL=191 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	4
LITTER			PLANT LITTER	6
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	4
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	12
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	19
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	52
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	32
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	88
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	40
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	3
SHRUBS		NATIVE	BACCHARIS PILULARIS	4
SHRUBS		NATIVE	LUPINUS ARBOREUS	7

CELL=191 YR=81 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	12
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	5
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	2
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	25
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	14
FORBS	ANNUAL/BIENNIAL	NATIVE	LOTUS HUMISTRATUS	3
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	8
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	21
FORBS	PERENNIAL	NATIVE	OXALIS PILOSA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	44
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	34
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	SPERGULA ARVENSIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	TRIFOLIUM GRACILENTUM	7
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	1
FORBS	UNKNOWN	UNKNOWN	VICIA SP	12
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	25
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	29
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	15
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	85
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	32
SHRUBS		NATIVE	BACCHARIS PILULARIS	5
SHRUBS		NATIVE	LUPINUS ARBOREUS	1

CELL=195 YR=80 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	19
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	11
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	9
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	14
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	8
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	57
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	19

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	57
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	51
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	11
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	JUNCUS BUFONIUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	34
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	65
SHRUBS		NATIVE	LUPINUS ARBOREUS	26

CELL=195 YR=81 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	30
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	5
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	11
FORBS	PERENNIAL	EXOTIC	CERASTIUM ARVENSE	17
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	23
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	26
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO ARABICA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	41
FORBS	PERENNIAL	EXOTIC	NASTURTIUM OFFICINALE	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	10
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	10
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	24
FORBS	PERENNIAL	EXOTIC	RUMEX CRISPUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	96
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	50
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	75
GRASSES/SEDGES	PERENNIAL	NATIVE	GLYCERIA OCCIDENTALIS	7
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	46
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	26
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	9
GRASSES/SEDGES	PERENNIAL	EXOTIC	POA TRIVIALIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	14
SHRUBS		NATIVE	RUBUS URSINUS	3

CELL=204 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	8
LITTER			PLANT LITTER	11
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	7
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	46
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	16
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	22
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	56
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	JUNCUS BUFONIUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	72
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	13
SHRUBS		NATIVE	LUPINUS ARBOREUS	4

CELL=204 YR=81 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	34
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	4
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	5
FORBS	PERENNIAL	NATIVE	OXALIS PILOSA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	15
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	18
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	TRIFOLIUM GRACILENTUM	1
FORBS	UNKNOWN	UNKNOWN	VICIA SP	8
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	36
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	53
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	56
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	21
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	78

GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	21

CELL=205 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	23
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	3
FORBS	UNKNOWN	EXOTIC	MEDICAGO SP	4
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	35
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	29
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	50
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	2
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	89
SHRUBS		NATIVE	BACCHARIS PILULARIS	3
SHRUBS		NATIVE	LUPINUS ARBOREUS	10

CELL=205 YR=81 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	FREQUECCY
BARE GROUND			BARE GROUND	2
LITTER			PLANT LITTER	2
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	UNKNOWN	NATIVE	CARDAMINE OLIGOSPERMA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	5
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	6
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	4
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	40
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	19
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	4

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	90
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	8
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	52
SHRUBS		NATIVE	BACCHARIS PILULARIS	12

CELL=216 YR=80 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	11
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	42
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	21
FORBS	PERENNIAL	EXOTIC	SONCHUS ARVENIS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	40
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	54
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	27
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	72
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	20
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	24
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	92
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	4
SHRUBS		NATIVE	LUPINUS ARBOREUS	4

CELL=216 YR=81 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	2
LITTER			PLANT LITTER	6
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	9
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	4
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	UNKNOWN	EXOTIC	ERECHTITES PRENANTHOIDES	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	4
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	3
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	4
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	23
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	38
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	16
FORBS	ANNUAL/BIENNIAL	EXOTIC	SHERARDIA ARVENSIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1

FORBS	UNKNOWN	UNKNOWN	SOLANUM NODIFLORUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	5
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	16
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	81
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	29
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	49
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	15
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	4
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	28
SHRUBS		NATIVE	LUPINUS ARBOREUS	.

CELL=217 YR=80 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	27
FORBS	UNKNOWN	NATIVE	EPILOBIUM SP	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	5
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	41
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	46
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	41
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	71
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	14
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	85
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	5

CELL=217 YR=81 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	1
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	4
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	2
FORBS	UNKNOWN	NATIVE	EPILOBIUM SP	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2
FORBS	UNKNOWN	EXOTIC	LYTHRUM HYSSOPIFOLIA	1
FORBS	PERENNIAL	NATIVE	MIMULUS GUTTATUS	6
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	9
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	49
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	2

FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	13
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	8
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	13
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	39
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	70
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	48
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	20
SHRUBS		NATIVE	LUPINUS ARBOREUS	2

CELL=238 YR=80 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	4
LITTER			PLANT LITTER	23
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	6
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	2
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	2
FORBS	PERENNIAL	EXOTIC	CERASTIUM ARVENSE	1
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	2
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	4
FORBS	PERENNIAL	UNKNOWN	DICENTRA FORMOSA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	1
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	2
FORBS	ANNUAL/BIENNIAL	NATIVE	GNAPHALIUM CALIFORNICUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	4
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	13
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	UNKNOWN	EXOTIC	MEDICAGO SP	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	30
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	2
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	39
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	23
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	1
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	40
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	9

GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	32
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	34
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	8
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	16
SHRUBS		NATIVE	RHUS DIVERSILOBA	7
SHRUBS		UNKNOWN	RUBUS SPP	1
SHRUBS		NATIVE	RUBUS PARVIFLORUS	6
SHRUBS		NATIVE	SYMPHORICARPUS RIVULARIS	3

CELL=238 YR=81 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	2
LITTER			PLANT LITTER	2
LOWER PLANTS		NATIVE	DRYOPTERIS ARGUTA	2
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	3
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	3
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	2
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	8
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	2
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	2
FORBS	PERENNIAL	UNKNOWN	DICENTRA FORMOSA	5
FORBS	UNKNOWN	EXOTIC	ERECHTITES PRENANTHOIDES	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	3
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	3
FORBS	PERENNIAL	NATIVE	GRINDELIA STRICTA	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	5
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	19
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	5
FORBS	PERENNIAL	NATIVE	MIMULUS GUTTATUS	3
FORBS	PERENNIAL	NATIVE	OENANTHE SARMENTOSA	7
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	12
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	9
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	2
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SHERARDIA ARVENSIS	1
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	8
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	4
FORBS	PERENNIAL	NATIVE	SIDALCEA MALVAEFLORA	1
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SONCHUS ASPER	2
FORBS	ANNUAL/BIENNIAL	NATIVE	TRIFOLIUM MACRAEI	1
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	79
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	1

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	11
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	81
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	86
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	6
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	4
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	17
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	69
SHRUBS	PERENNIAL	NATIVE	RUBUS SPECTABILIS	1
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	7
SHRUBS		NATIVE	.ARTIMISIA CALIFORNICA	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	16
SHRUBS		NATIVE	LONICERA INVOLUCRATA	4
SHRUBS		NATIVE	MIMULUS AURANTIACUS	2
SHRUBS		NATIVE	RHUS DIVERSILOBA	13
SHRUBS		NATIVE	RUBUS PARVIFLORUS	4
SHRUBS		NATIVE	RUBUS SPECTABILIS	2

CELL=246 YR=80 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	32
LITTER			PLANT LITTER	25
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	13
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	6
FORBS	PERENNIAL	UNKNOWN	CARDIONEMA RAMOSISSIMA	2
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	4
FORBS	ANNUAL/BIENNIAL	NATIVE	NAVARRETIA SQUARROSA	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	31
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	15
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	16
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	16
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	33
SHRUBS		NATIVE	LUPINUS ARBOREUS	15
SHRUBS		NATIVE	RUBUS PARVIFLORUS	2

CELL=246 YR=81 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	19
LITTER			PLANT LITTER	18
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	22
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	3
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	1
FORBS	PERENNIAL	UNKNOWN	CARDIONEMA RAMOSISSIMA	11
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1

FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	20
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	16
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	ANNUAL/BIENNIAL	NATIVE	LINANTHUS ANDROSACEUS	3
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	17
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PHACELIA MALVIFOLIA	4
FORBS	UNKNOWN	UNKNOWN	PLAGIOBOTHRYS SP	5
FORBS	ANNUAL/BIENNIAL	NATIVE	PLATYSTEMON CALIFORNICUS	10
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	72
FORBS	ANNUAL/BIENNIAL	EXOTIC	SCANDIX PECTEN-VENERIS	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	SENECIO VULGARIS	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SPERGULA ARVENSIS	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	29
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	13
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	42
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	71
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	9
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	32
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	1
SHRUBS		NATIVE	BACCHARIS PILULARIS	4
SHRUBS		NATIVE	LUPINUS ARBOREUS	13
SHRUBS		NATIVE	RHUS DIVERSILOBA	2

CELL=254 YR=80 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	85
LICHENS			RAMALINA MENZIESII	3
LOWER PLANTS		NATIVE	DRYOPTERIS ARGUTA	1
LOWER PLANTS		UNKNOWN	MOSS	4
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	7
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	3
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	17
FORBS	UNKNOWN	EXOTIC	ERECHTITES PRENANTHOIDES	3
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	2
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	11
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	1
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	12
FORBS	UNKNOWN	UNKNOWN	SONCHUS SP	1

FORBS	ANNUAL/BIENNIAL	EXOTIC	SOLANUM SARACHOIDES	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	5
FORBS	PERENNIAL	NATIVE	URTICA CALIFORNICA	9
SHRUBS		NATIVE	BACCHARIS PILULARIS	12
SHRUBS		NATIVE	HOLODISCUS DISCOLOR	1
SHRUBS		NATIVE	LONICERA HISPIDULA	4
SHRUBS		NATIVE	MIMULUS AURANTIACUS	3
SHRUBS		NATIVE	MYRICA CALIFORNICA	29
SHRUBS		NATIVE	RHUS DIVERSILOBA	13
SHRUBS		UNKNOWN	RIBES SPP	4
SHRUBS		UNKNOWN	RUBUS SPP	3
SHRUBS		NATIVE	RUBUS PARVIFLORUS	3
SHRUBS		NATIVE	SAMBUCUS CALLICARPA	9
SHRUBS		NATIVE	SALIX HINDSIANA	44

CELL=254 YR=81 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	22
LITTER			PLANT LITTER	16
LOWER PLANTS		NATIVE	DRYOPTERIS ARGUTA	1
LOWER PLANTS		UNKNOWN	MOSS	4
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	5
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	4
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	3
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	8
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	51
FORBS	UNKNOWN	EXOTIC	ERECHTITES PRENANTHOIDES	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GALIUM APARINE	10
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	19
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	60
FORBS	ANNUAL/BIENNIAL	NATIVE	HESPEROCNIDE TENELLA	15
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	10
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	15
FORBS	PERENNIAL	NATIVE	SANICULA CRASSICAULIS	2
FORBS	PERENNIAL	NATIVE	SMILACINA RACEMOSA	1
FORBS	PERENNIAL	NATIVE	SMILACINA STELLATA	21
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	7
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	9
FORBS	PERENNIAL	NATIVE	URTICA CALIFORNICA	25
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
SHRUBS		NATIVE	ARTIMISIA CALIFORNICA	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	31
SHRUBS		NATIVE	LONICERA HISPIDULA	7
SHRUBS		NATIVE	MIMULUS AURANTIACUS	5
SHRUBS		NATIVE	MYRICA CALIFORNICA	39
SHRUBS		NATIVE	RHUS DIVERSILOBA	28
SHRUBS		NATIVE	RUBUS PARVIFLORUS	4
SHRUBS		NATIVE	RUBUS URSINUS	5
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1
SHRUBS		NATIVE	SAMBUCUS CALLICARPA	12

SHRUBS		NATIVE	SALIX HINDSIANA	73

CELL=263 YR=80 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
UNKNOWN			UNKNOWN PLANT	1
LITTER			PLANT LITTER	7
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	3
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	8
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	1
FORBS	UNKNOWN	EXOTIC	ERECHTITES PRENANTHOIDES	2
FORBS	PERENNIAL	NATIVE	GALIUM CALIFORNICUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	27
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	11
FORBS	PERENNIAL	EXOTIC	NASTURTIUM OFFICINALE	1
FORBS	PERENNIAL	NATIVE	OENANTHE SARMENTOSA	3
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	4
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	33
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	1
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	35
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	59
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	16
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	6
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	12
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	3
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	20
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	76
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	5
SHRUBS		NATIVE	LUPINUS ARBOREUS	27
SHRUBS		UNKNOWN	RUBUS SPP	14

CELL=263 YR=81 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	8
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	7
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	32
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	PERENNIAL	NATIVE	CIRSIUM OCCIDENTALE	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	4

FORBS	PERENNIAL	NATIVE	FRANSERIA CHAMISSONIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	18
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	69
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	41
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	75
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	6
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	29
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	14
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	5
FORBS	ANNUAL/BIENNIAL	NATIVE	TRIFOLIUM GRACILENTUM	1
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	1
FORBS	UNKNOWN	UNKNOWN	VICIA SP	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA SATIVA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	21
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	9
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	82
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	35
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	40
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	BERBERIS PINNATA	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	12
SHRUBS		NATIVE	RUBUS VITIFOLIUS	23

CELL=264 YR=80 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	15
LITTER			PLANT LITTER	24
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	6
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CHORIZANTHE CUSPIDATA	5
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	ANNUAL/BIENNIAL	NATIVE	PHACELIA CALIFORNICA	3
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	40
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	11
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	20

GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	91
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	3
SHRUBS		NATIVE	LUPINUS ARBOREUS	8
SHRUBS		UNKNOWN	RUBUS SPP	2

CELL=264 YR=81 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	28
LITTER			PLANT LITTER	41
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	11
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	8
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	92
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	4
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	1
FORBS	PERENNIAL	UNKNOWN	CARDIONEMA RAMOSISSIMA	7
FORBS	ANNUAL/BIENNIAL	NATIVE	CHORIZANTHE CUSPIDATA	4
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	5
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	4
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	2
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	6
FORBS	ANNUAL/BIENNIAL	NATIVE	LEPIDIUM NITIDUM	2
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	14
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PHACELIA CALIFORNICA	2
FORBS	UNKNOWN	UNKNOWN	PLAGIOBOTHRYS SP	36
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	28
FORBS	ANNUAL/BIENNIAL	EXOTIC	SENECIO VULGARIS	6
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	97
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	26
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	7
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	97
SHRUBS		NATIVE	BACCHARIS PILULARIS	2
SHRUBS		NATIVE	LUPINUS ARBOREUS	14
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1

CELL=282 YR=80 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	6
LITTER			PLANT LITTER	19
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	11
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	6

FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	13
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	18
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	2
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	41
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	49
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	12
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	49
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	14
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	53
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	25
SHRUBS		UNKNOWN	RUBUS SPP	2

CELL=282 YR=81 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	1
LITTER			PLANT LITTER	40
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	8
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	21
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	2
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	2
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	3
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	80
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	51
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	7
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS HALII	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	12
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	11
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	79
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	53
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	34
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	10
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	26
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	3
SHRUBS		NATIVE	LUPINUS ARBOREUS	18
SHRUBS		NATIVE	RHUS DIVERSILOBA	2
SHRUBS		NATIVE	RUBUS URSINUS	3

CELL=285 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	38
LOWER PLANTS	PERENNIAL	NATIVE	POLYSTICHUM CALIFORNICUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	2
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	2
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	12
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	22
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	36
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	27
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	48
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	6
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	6
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	66
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	19
				303

CELL=285 YR=81 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	3
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	10
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	23
FORBS	ANNUAL/BIENNIAL	NATIVE	BAERIA MINOR	2
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	5
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	5
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	6
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	34
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO HISPIDA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	6
FORBS	ANNUAL/BIENNIAL	NATIVE	ORTHOCARPUS PUSILLUS	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	20
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	3
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	35
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	1
FORBS	ANNUAL/BIENNIAL	NATIVE	TRIFOLIUM MACRAEI	1

FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	10
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	99
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	59
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	64
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	60
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	69
SHRUBS		NATIVE	LUPINUS ARBOREUS	12
				555

CELL=287 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	5
LITTER			PLANT LITTER	13
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	8
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	8
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	8
FORBS	PERENNIAL	NATIVE	CIRSIUM OCCIDENTALE	1
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	5
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	5
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	8
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	6
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	31
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	77
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	30
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	13
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	83
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	11
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	32
SHRUBS		NATIVE	BACCHARIS PILULARIS	11
SHRUBS		NATIVE	BERBERIS PINNATA	2
SHRUBS		NATIVE	LUPINUS ARBOREUS	12
SHRUBS		NATIVE	RHUS DIVERSILOBA	5

CELL=287 YR=81 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
LITTER			PLANT LITTER	7
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	15
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	10
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	5
FORBS	ANNUAL/BIENNIAL	NATIVE	CALANDRINIA CILIATA	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	23
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	2

FORBS	ANNUAL/BIENNIAL	EXOTIC	CONIUM MACULATUM	3
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	6
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	1
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	17
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	22
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	HYPOCHOERIS GLABRA	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	26
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	41
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	2
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	53
FORBS	ANNUAL/BIENNIAL	EXOTIC	SENECIO VULGARIS	1
FORBS	PERENNIAL	NATIVE	STELLARIA JAMESIANA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	3
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	8
FORBS	UNKNOWN	UNKNOWN	VICIA SP	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA SATIVA	1
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	9
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	92
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	19
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	39
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	15
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	74
SHRUBS		NATIVE	BACCHARIS PILULARIS	17
SHRUBS		NATIVE	LUPINUS ARBOREUS	6
SHRUBS		NATIVE	RHUS DIVERSILOBA	5
SHRUBS		NATIVE	RUBUS URSINUS	2

CELL=299 YR=80 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	3
LITTER			PLANT LITTER	7
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	2
FORBS	UNKNOWN	NATIVE	CHLOROGALUM POMERIDIANUM	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	11
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	94
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	46
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	46
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	42
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	42

SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	2
SHRUBS		NATIVE	LUPINUS ARBOREUS	1

CELL=299 YR=81 SECTION=SOUTH ASPECT=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	4
LITTER			PLANT LITTER	1
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	1
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	CARDUUS PYCNOCEPHALUS	9
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	7
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM MOSCHATUM	2
FORBS	UNKNOWN	NATIVE	ESCHSCHOLZIA CALIFORNICA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	12
FORBS	PERENNIAL	NATIVE	HERACLEUM LANATUM	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	4
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	40
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	23
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	1
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	2
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	10
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	80
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	36
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	5
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	60
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	33
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	RHUS DIVERSILOBA	4

CELL=302 YR=80 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
UNKNOWN			UNKNOWN PLANT	2
BARE GROUND			BARE GROUND	7
LITTER			PLANT LITTER	3
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	4
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	13
FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEI	1
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	12
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	1

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	15
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	34
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	2
GRASSES/SEDGES	PERENNIAL	EXOTIC	DACTYLIS GLOMERATA	1
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	45
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	45
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	10
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	52
GRASSES/SEDGES	PERENNIAL	EXOTIC	PLANTAGO MAJOR	3
SHRUBS	PERENNIAL	NATIVE	MALACOTHRIX SAXATILIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	2

CELL=302 YR=81 SECTION=SOUTH ASPECT=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
LITTER			PLANT LITTER	8
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	9
FORBS	ANNUAL/BIENNIAL	NATIVE	AMSINCKIA INTERMEDIA	15
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	2
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	2
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	9
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	9
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	6
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	2
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	93
FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEI	11
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	51
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM CALIFORNICUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	SPERGULA ARVENSIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	STELLARIA MEDIA	6
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	7
FORBS	PERENNIAL	NATIVE	TRIFOLIUM WORMSKIOLDI	7
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA HIRSUTA	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	VICIA SATIVA	3
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	1
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	4
GRASSES/SEDGES	ANNUAL/BIENNIAL	NATIVE	BROMUS CARINATUS	21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	48
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	18
GRASSES/SEDGES	UNKNOWN	UNKNOWN	CAREX	3
GRASSES/SEDGES	PERENNIAL	EXOTIC	DACTYLIS GLOMERATA	10
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	79
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	38
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	77
GRASSES/SEDGES	PERENNIAL	NATIVE	JUNCUS EFFUSUS	14
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	78
GRASSES/SEDGES	PERENNIAL	NATIVE	MELICA GEYERI	4
GRASSES/SEDGES	PERENNIAL	EXOTIC	POA BULBOSA	1

SHRUBS	PERENNIAL	NATIVE	RHAMNUS CALIFORNICA	2
SHRUBS		NATIVE	BACCHARIS PILULARIS	1
SHRUBS		NATIVE	LUPINUS ARBOREUS	5

CELL=317 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	9
LITTER			PLANT LITTER .	8
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENIS	3
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	13
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	2
FORBS	ANNUAL/BIENNIAL	NATIVE	NAVARRETIA SQUARROSA	1
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	14

CELL=317 YR=80 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	7
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MINOR	3
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	1
GRASSES/SEDGES	PERENNIAL	NATIVE	ELYMUS GLAUCUS	11
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	37
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	35
SHRUBS		NATIVE	BACCHARIS PILULARIS	4
SHRUBS		NATIVE	BERBERIS PINNATA	1
SHRUBS		NATIVE	RHUS DIVERSILOBA	2

CELL=317 YR=81 SECTION=SOUTH ASPECT=LEVEL

PLANT TYPE	GROWTH	STATUS	SPECIES	NO. HITS
BARE GROUND			BARE GROUND	4
LITTER			PLANT LITTER	5
LOWER PLANTS	PERENNIAL	NATIVE	PTERIDIUM AQUILINUM	5
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	4
FORBS	PERENNIAL	EXOTIC	ANGELICA ARGUTA	3
FORBS	ANNUAL/BIENNIAL	EXOTIC	CERASTIUM VISCOSCUM	1
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	1
FORBS	PERENNIAL	NATIVE	ERODIUM CICUTARIUM	1
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM MOLLE	8
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	6
FORBS	PERENNIAL	NATIVE	LUPINUS VARIICOLOR	10
FORBS	PERENNIAL	NATIVE	MARAH FABACEUS	1
FORBS	ANNUAL/BIENNIAL	NATIVE	PLANTAGO HOOKERIANA	1

APPENDIX II. Plant taxa recorded in the diet of elk and deer in each sample period.

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15FEB79 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.95
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	0.65
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	4.64
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.65
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	3.28
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	5.93
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	6.74
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	14.26
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	2.61
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	5.98
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	5.33
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	8.17
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	15.89
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	1.29
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	6.74
SHRUBS		NATIVE	LUPINUS	15.89

28MAY79 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	1.02
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	3.67
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.02
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	8.82
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.51
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2.59
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	8.82
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	53.07
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.51
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	8.82
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	10.65
SHRUBS		NATIVE	LUPINUS	0.51

15OCT79 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.32
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	4.55
FORBS	PERENNIAL	EXOTIC	ANAPHALIS MARGARITACEA	6.01
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	4.07
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.76
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.99
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1.31
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.44

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	ARTEMISIA	56.47
SHRUBS		NATIVE	BACCHARIS PILULARIS	3.60
SHRUBS		NATIVE	LUPINUS	10.17
SHRUBS		UNKNOWN	UNKWN SHRUB	5.34

15NOV79 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	2.96
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.73
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO SP	4.49
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.73
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.73
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.46
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.46
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.73
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	0.73
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.73
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	0.73
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	4.99
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	22.31
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	5.99
SHRUBS		NATIVE	ARTEMISIA	48.79
SHRUBS		NATIVE	BACCHARIS PILULARIS	0.73
SHRUBS		UNKNOWN	UNKWN SHRUB	0.73
TREES		EXOTIC	CUPRESSUS SARGENTII	0.73
TREES		NATIVE	PINUS MURICATA	0.73

15DEC79 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.55
FORBS	ANNUAL/BIENNIAL	NATIVE	NEMOPHILA MENZIESII	1.65
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	5.76
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2.21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	4.52
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	22.50
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	17.04
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	8.80
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	0.55
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	11.65
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.55
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	6.31
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.78
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	1.09
SHRUBS		NATIVE	ARTEMISIA	10.75
SHRUBS		NATIVE	LUPINUS	1.09
TREES		EXOTIC	CUPRESSUS SARGENTII	2.21

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15DEC79 BLACK-TAILED DEER

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.50
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.50
FORBS	UNKNOWN	UNKNOWN	HEMIZONIA SP	3.09
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.09
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.52
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1.01
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.50
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	21.48
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	2.02
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	2.56
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.53
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	2.03
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	0.50
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	1.52
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.52
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	4.16
SHRUBS		NATIVE	BACCHARIS PILULARIS	5.81
SHRUBS		NATIVE	GAULTHERIA SHALLON	2.03
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	1.52
SHRUBS		NATIVE	LONICERA INVOLUCRATA	11.75
SHRUBS		NATIVE	LUPINUS	8.69
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	4.16
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1.01
SHRUBS		NATIVE	VACCINIUM OVATUM	3.09
SHRUBS		UNKNOWN	UNKWN SHRUB	4.06
TREES		EXOTIC	CUPRESSUS SARGENTII	5.25
TREES		NATIVE	MYRICA CALIFORNICA	3.09
TREES		NATIVE	SALIX HINDSIANA	1.01

15JAN80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	2.50
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2.10
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO SP	6.50
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.40
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	3.60
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	8.60
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	4.81
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.10
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	6.50
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1.80
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.40
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	0.70
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	0.70
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	4.40
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	9.60
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	2.90

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	5.20
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	5.60
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	7.30
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	1.80
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	0.7
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	0.7
SHRUBS		NATIVE	ARTEMISIA	21.3
SHRUBS		NATIVE	RHUS DIVERSILOBA	0.7

15FEB80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.97
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	2.32
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1.98
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	MONERMA CYLINDRICA	1.64
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	0.65
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	4.82
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	2.66
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	5.19
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1.64
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.97
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.32
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	0.65
GRASSES/SEDGES	PERENNIAL	NATIVE	GLYCERIA OCCIDENTALIS	2.32
SHRUBS		NATIVE	ARTEMISIA	73.55
SHRUBS		NATIVE	LUPINUS	0.32

15FEB80 BLACK-TAILED DEER

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	2.21
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.87
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	1.32
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.06
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	12.99
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.44
FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEII	2.21
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	2.21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	1.76
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	1.32
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	6.51
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	4.55
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	17.28
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	1.32
SHRUBS		NATIVE	LUPINUS	29.91
SHRUBS		ATIVE	MIMULUS AURANTIACUS	0.87
SHRUBS		NATIVE	VACCINIUM OVATUM	0.44
TREES		EXOTIC	CUPRESSUS SARGENTII	10.72

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15MAR80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	0.48
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	1.22
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.24
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	6.22
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.73
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	14.23
FORBS	UNKNOWN	UNKNOWN	HEMIZONIA SP	0.48
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.97
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	2.25
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.22
FORBS	PERENNIAL	EXOTIC	RUMEX	0.73
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.73
FORBS	PERENNIAL	NATIVE	MIMULUS GUTTATUS	0.97
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	0.24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.73
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	0.24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	0.97
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	2.25
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	0.73
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	5.31
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	2.25
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	4.15
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.73
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	0.48
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.92
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	5.92
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.24
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	5.92
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	1.47
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	1.22
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	0.73
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	0.24
SHRUBS		NATIVE	ARTEMISIA	25.81

15MAR80 BLACK-TAILED DEER

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	2.44
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	5.02
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	3.46
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.96
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	8.31
FORBS	UNKNOWN	NATIVE	LOTUS SP	3.46
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.94
FORBS	UNKNOWN	UNKNOWN	TRIFOLIUM	2.44
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	3.97
FORBS	PERENNIAL	EXOTIC	RUMEX	4.49
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.45

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEII	7.74
FORBS	PERENNIAL	NATIVE	STACHYS BULLATA	0.96
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	10.63
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	14.35
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	0.48
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	6.09
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.45
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.96
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1.45
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.48
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	4.49
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	0.48
SHRUBS		NATIVE	LUPINUS	3.46
SHRUBS		NATIVE	RHUS DIVERSILOBA	5.02
TREES		NATIVE	MYRICA CALIFORNICA	3.97

15APR80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	3.91
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	3.91
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	9.88
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	8.34
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	2.40
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	2.90
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.90
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.91
FORBS	PERENNIAL	EXOTIC	RUMEX	0.95
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.43
FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	2.40
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.90
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1.43
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	4.94
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3.35
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.95
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	4.94
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.91
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	1.91
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	13.48
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.47
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	9.30
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	3.40
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	8.17
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	2.90

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15APR80 BLACK-TAILED DEER

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.98
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	1.49
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	2.54
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.75
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	8.48
FORBS	UNKNOWN	UNKNOWN	BAERIA SP	0.24
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.24
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.74
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	60.97
FORBS	PERENNIAL	EXOTIC	RUMEX	0.98
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3.92
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	1.49
FORBS	PERENNIAL	NATIVE	CONVOLVULUS OCCIDENTALIS	0.24
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.49
FORBS	PERENNIAL	NATIVE	MIMULUS SP	2.04
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	0.24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.49
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	0.24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	1.49
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.24
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	0.49
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.24
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	0.74
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.74
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.24
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.24
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.49
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.24
SHRUBS		NATIVE	ARTEMISIA	0.74
SHRUBS		NATIVE	LONICERA HISPIDULA	0.74
SHRUBS		NATIVE	LUPINUS	2.81
SHRUBS		NATIVE	RUBUS VITIFOLIUS	0.74
TREES		NATIVE	MYRICA CALIFORNICA	0.24

15MAY80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	1.78
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.70
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1.78
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.06
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1.41
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.35
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.70
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	8.50
FORBS	PERENNIAL	EXOTIC	LOTUS SP	1.41
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	21.33
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.78

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	CIRSIUM QUERCETORUM	14.91
FORBS	PERENNIAL	NATIVE	ERYNGIUM ARMATUM	4.42
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.70
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	1.41
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	0.70
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	2.14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	0.70
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.41
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.78
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	1.78
SHRUBS		NATIVE	BACCHARIS PILULARIS	0.35
SHRUBS		NATIVE	LUPINUS	25.41
SHRUBS		UNKNOWN	UNKWN SHRUB	3.65

15MAY80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	1.40
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	1.40
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2.85
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	12.87
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.86
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	4.85
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	47.00
FORBS	PERENNIAL	EXOTIC	RUMEX	1.88
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	0.93
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.46
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	2.36
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	2.36
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.93
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	0.46
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	5.22
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.36
SHRUBS		NATIVE	ARTEMISIA	0.93
SHRUBS		NATIVE	LUPINUS	1.88
SHRUBS		NATIVE	RHUS DIVERSILOBA	8.02

28MAY80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	11.12
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1.21
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3.06
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	22.16
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	7.63
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.60
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	5.63
FORBS	PERENNIAL	EXOTIC	RUMEX	8.32
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	3.70
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.82

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	3.06
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3.06
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	19.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	4.98
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.60
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.44
SHRUBS		NATIVE	LUPINUS	0.60
TREES		EXOTIC	CUPRESSUS SARGENTII	0.60

15JUN80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	14.31
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	11.09
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.39
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO SP	.78
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.78
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	2.39
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	1.57
FORBS	UNKNOWN	UNKNOWN	HEMIZONIA SP	0.39
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.98
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.64
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	11.09
FORBS	PERENNIAL	EXOTIC	RUMEX	1.18
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7.65
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	0.39
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	0.78
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.78
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	1.18
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	27.89
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.39
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	10.58
TREES		NATIVE	SALIX HINDSIANA	0.39

15JUN80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	0.97
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	2.23
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.97
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	70.89
FORBS	PERENNIAL	EXOTIC	RUMEX	13.72
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.97
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.72
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.72
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	0.24
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.21
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	0.24
SHRUBS		NATIVE	LONICERA HISPIDULA	0.72
SHRUBS		NATIVE	LUPINUS	2.76

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	RHUS DIVERSILOBA	0.72
SHRUBS		NATIVE	RUBUS VITIFOLIUS	0.48
SHRUBS		NATIVE	VACCINIUM OVATUM	0.24
SHRUBS		UNKNOWN	UNKWN SHRUB	0.24
TREES		NATIVE	SALIX HINDSIANA	0.97

15JUN80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO SP	0.43
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.65
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	0.43
FORBS	UNKNOWN	UNKNOWN	BAERIA SP	2.97
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.65
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.22
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	68.72
FORBS	PERENNIAL	EXOTIC	RUMEX	20.66
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.55
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	0.43
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.22
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	0.22
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.10
SHRUBS		NATIVE	LUPINUS	1.55
TREES		NATIVE	SALIX HINDSIANA	0.22

28JUN80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LICHENS	UNKNOWN	UNKNOWN	UNKNWN LICHEN	0.80
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	8.30
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	3.29
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2.44
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	1.61
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	0.80
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.61
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	4.52
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.40
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	18.21
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7.82
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.40
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	0.80
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1.61
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	1.61
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	1.61
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.80
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	1.20
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	30.55
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.40
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	3.72
SHRUBS		NATIVE	ARTEMISIA	5.94

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	LUPINUS	1.20
TREES		NATIVE	SALIX HINDSIANA	0.40

15JUL80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	1.56
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	2.08
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	4.28
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.52
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.04
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	14.07
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	2.09
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	13.73
FORBS	PERENNIAL	EXOTIC	RUMEX	0.52
FORBS	PERENNIAL	NATIVE	SATUREJA DOUGLASII	0.52
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	0.52
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	17.17
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	4.83
SHRUBS		NATIVE	LONICERA INVOLUCRATA	0.52
SHRUBS		NATIVE	VACCINIUM OVATUM	0.52
TREES		NATIVE	MYRICA CALIFORNICA	0.52
TREES		NATIVE	SALIX HINDSIANA	35.53

15JUL80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	2.00
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.79
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	0.79
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	4.98
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	6.33
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	11.21
FORBS	PERENNIAL	EXOTIC	RUMEX	4.54
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3.67
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.79
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	12.26
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1.59
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	0.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	6.22
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.19
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	10.19
SHRUBS		NATIVE	LUPINUS	12.26
SHRUBS		NATIVE	RUBUS SPP	2.00
SHRUBS		NATIVE	SAMBUCUS	2.00
TREES		NATIVE	SALIX HINDSIANA	4.11

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15JUL80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.70
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	0.70
FORBS	UNKNOWN	NATIVE	LOTUS SP	2.15
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	5.24
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	4.44
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	8.26
FORBS	UNKNOWN	UNKNOWN	VICIA SP	0.35
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.35
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	30.16
FORBS	PERENNIAL	EXOTIC	RUMEX	5.65
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.70
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.90
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	0.35
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	2.15
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.35
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	0.35
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.35
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.15
SHRUBS		NATIVE	LUPINUS	6.06
SHRUBS		NATIVE	SAMBUCUS	0.35
TREES		NATIVE	SALIX HINDSIANA	14.98

28JUL80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
SEAWEED		NATIVE	ULVA	0.58
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	2.97
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.58
FORBS	ANNUAL/BIENNIAL	EXOTIC	MADIA SATIVA	6.10
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.58
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	11.48
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.76
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.58
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	1.17
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.76
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	3.58
FORBS	PERENNIAL	EXOTIC	RUMEX	0.58
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.36
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	0.58
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	7.39
FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEI	2.97
FORBS	PERENNIAL	NATIVE	PRUNELLA VULGARIS	0.58
FORBS	PERENNIAL	NATIVE	SMILACINA SP	0.58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA MYUROS	1.17
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	3.58
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	1.76
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.82

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1.17
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	2.36
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1.17
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	7.39
GRASSES/SEDGES	PERENNIAL	NATIVE	HIEROCHLOE OCCIDENTALIS	1.17
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	10.77
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	1.17
SHRUBS		NATIVE	LONICERA HISPIDULA	2.36
SHRUBS		NATIVE	LUPINUS	1.17
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	0.58
SHRUBS		UNKNOWN	UNKWN SHRUB	1.76
TREES		NATIVE	MYRICA CALIFORNICA	1.76
TREES		NATIVE	SALIX HINDSIANA	3.58

15AUG80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	5.29
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.64
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	1.28
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.28
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	0.64
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.64
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	19.48
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	4.60
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	10.31
FORBS	PERENNIAL	EXOTIC	RUMEX	0.64
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.28
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	0.64
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	5.98
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	12.15
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	3.93
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1.93
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	8.10
SHRUBS		NATIVE	LUPINUS	13.36
TREES		NATIVE	MYRICA CALIFORNICA	0.64
TREES		NATIVE	SALIX HINDSIANA	3.93

15AUG80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.90
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	1.36
FORBS	UNKNOWN	UNKNOWN	BRASSICA NIGRA	2.29
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	5.19
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	5.19
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	12.10
FORBS	PERENNIAL	EXOTIC	RUMEX	2.27
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.29
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.36

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEI	0.45
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.45
FORBS	PERENNIAL	NATIVE	STACHYS BULLATA	1.82
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	3.19
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.45
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.90
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.45
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	23.89
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.45
SHRUBS		NATIVE	LUPINUS	14.02
SHRUBS		NATIVE	MIMULUS AURANTIACUS	0.45
SHRUBS		NATIVE	RHUS DIVERSILOBA	17.84
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1.82
TREES		NATIVE	MYRICA CALIFORNICA	0.45
TREES		NATIVE	SALIX HINDSIANA	0.45

15AUG80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.54
FORBS	UNKNOWN	UNKNOWN	BAERIA SP	0.54
FORBS	UNKNOWN	UNKNOWN	BRASSICA NIGRA	0.54
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.07
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	6.80
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	9.91
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.62
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	30.80
FORBS	PERENNIAL	EXOTIC	RUMEX	3.29
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.07
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.17
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	6.15
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.62
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	4.44
SHRUBS		NATIVE	LUPINUS	21.30
SHRUBS		NATIVE	RHUS DIVERSILOBA	2.73
SHRUBS		NATIVE	SAMBUCUS	1.07
TREES		NATIVE	MYRICA CALIFORNICA	2.17
TREES		NATIVE	SALIX HINDSIANA	2.17

28AUG80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	1.16
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	2.92
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	2.94
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.75
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.54
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	7.32
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	3.54
FORBS	PERENNIAL	EXOTIC	RUMEX	0.58

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.96
SHRUBS		NATIVE	LUPINUS	28.51
SHRUBS		NATIVE	RUBUS VITIFOLIUS	9.47
TREES		EXOTIC	CUPRESSUS SARGENTII	0.96
TREES		NATIVE	SALIX HINDSIANA	0.96

15SEP80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	3.06
FORBS	UNKNOWN	UNKNOWN	BRASSICA NIGRA	1.51
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	4.13
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.00
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.00
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.50
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	3.06
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	8.63
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	5.22
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.33
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.50
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	26.11
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.04
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.50
SHRUBS		NATIVE	ARTEMISIA	3.59
SHRUBS		NATIVE	LUPINUS	23.66
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	3.59
SHRUBS		UNKNOWN	UNKWN SHRUB	3.06
TREES		NATIVE	ALNUS SP	0.50

28SEP80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.13
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.13
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	3.47
FORBS	PERENNIAL	EXOTIC	RUMEX	11.80
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.57
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.57
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	2.29
FORBS	PERENNIAL	NATIVE	VERONICA AMERICANA	0.57
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	4.07
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	2.87
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	11.20
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	25.88
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	2.29
SHRUBS		NATIVE	BACCHARIS PILULARIS	4.07
SHRUBS		NATIVE	LUPINUS	13.20
TREES		NATIVE	MYRICA CALIFORNICA	1.71
TREES		NATIVE	SALIX HINDSIANA	13.20

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.16
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	13.50
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.16
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.16
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	14.64
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	9.30
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	8.63
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	0.58
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	0.58
SHRUBS		NATIVE	LUPINUS	10.66
TREES		NATIVE	MYRICA CALIFORNICA	1.75
TREES		NATIVE	SALIX HINDSIANA	6.67

15SEP80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.61
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	2.47
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.22
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.85
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	4.40
FORBS	PERENNIAL	EXOTIC	RUMEX	26.12
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	6.87
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	8.15
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1.22
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	13.53
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	12.77
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	5.72
GRASSES/SEDGES	PERENNIAL	NATIVE	GLYCERIA OCCIDENTALIS	1.22
SHRUBS		NATIVE	LUPINUS	1.85
TREES		EXOTIC	CUPRESSUS SARGENTII	3.11
TREES		NATIVE	MYRICA CALIFORNICA	2.47
TREES		NATIVE	SALIX HINDSIANA	6.39

15SEP80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	1.45
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	2.45
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	9.47
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	4.50
FORBS	PERENNIAL	EXOTIC	ANAPHALIS MARGARITACEA	12.47
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	7.75
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.95
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	0.48
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.95
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	11.24
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.48
FORBS	PERENNIAL	NATIVE	STACHYS RIGIDA	0.48
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.46

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15OCT80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.55
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	1.66
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.55
FORBS	UNKNOWN	NATIVE	EPILOBIUM SP	0.55
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	3.95
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.55
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.55
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2.79
FORBS	PERENNIAL	EXOTIC	RUMEX	2.79
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.10
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	1.10
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	1.66
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	4.54
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	3.37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	MONERMA CYLINDRICA	1.10
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.10
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.66
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	7.44
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	22.61
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.66
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.55
SHRUBS		NATIVE	BACCHARIS PILULARIS	1.10
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	2.22
SHRUBS		NATIVE	LUPINUS	31.55
TREES		EXOTIC	CUPRESSUS SARGENTII	1.10
TREES		NATIVE	SALIX HINDSIANA	2.22

15OCT80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	0.40
LOWER PLANTS		NATIVE	PTERIDIUM AQUILINUM	0.40
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	2.85
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	6.39
FORBS	ANNUAL/BIENNIAL	NATIVE	NEMOPHILA MENZIESII	1.20
FORBS	UNKNOWN	UNKNOWN	BRASSICA NIGRA	0.79
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	0.40
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.28
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.79
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.60
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	4.58
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	0.40
FORBS	PERENNIAL	NATIVE	MIMULUS GUTTATUS	0.40
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	0.79
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	0.40
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.40
SHRUBS		NATIVE	BACCHARIS PILULARIS	6.86
SHRUBS		NATIVE	GAULTHERIA SHALLON	6.39

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	LUPINUS	35.06
SHRUBS		NATIVE	RUBUS SPP	4.14
SHRUBS		NATIVE	SAMBUCUS	4.14
SHRUBS	UNKNOWN	UNKNOWN	UNKWN SHRUB	1.20
TREES		EXOTIC	CUPRESSUS SARGENTII	11.84
TREES		NATIVE	MYRICA CALIFORNICA	3.71
TREES		NATIVE	SALIX HINDSIANA	0.79

15OCT80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.34
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.34
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	1.03
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.55
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.73
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.73
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	5.47
FORBS	PERENNIAL	NATIVE	ASTER CHILENSIS	0.68
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.10
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	0.34
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.34
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.34
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	2.08
SHRUBS		NATIVE	LUPINUS	55.93
SHRUBS		NATIVE	RHUS DIVERSILOBA	2.08
SHRUBS		NATIVE	RUBUS SPP	3.18
SHRUBS		NATIVE	SAMBUCUS	4.30
SHRUBS		NATIVE	VACCINIUM OVATUM	0.34
SHRUBS		UNKNOWN	UNKWN SHRUB	6.00
TREES		NATIVE	MYRICA CALIFORNICA	1.37
TREES		NATIVE	SALIX HINDSIANA	1.73

28OCT80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	PTERIDIUM AQUILINUM	4.19
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.51
FORBS	UNKNOWN	UNKNOWN	GNAPHALIUM SP	1.02
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.02
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	0.51
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	MONERMA CYLINDRICA	1.02
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	4.19
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.02
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	3.11
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	6.77
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	37.95
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	11.85
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	7.58
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	0.51

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	LUPINUS	17.22
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1.02
TREES		NATIVE	SALIX HINDSIANA	0.51

15NOV80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	0.51
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	1.02
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	2.56
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.02
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	0.51
FORBS	PERENNIAL	EXOTIC	RUMEX	1.53
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	7.58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	1.02
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	8.17
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	2.05
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	16.12
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	41.27
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	5.86
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.53
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	0.51
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	3.65
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.02
SHRUBS		NATIVE	LUPINUS	2.05
TREES		EXOTIC	CUPRESSUS SARGENTII	2.05

15NOV80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	7.39
FORBS	ANNUAL/BIENNIAL	EXOTIC	MEDICAGO SP	1.62
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.54
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	3.28
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.62
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	11.18
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2.72
FORBS	PERENNIAL	EXOTIC	RUMEX	3.28
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.54
FORBS	PERENNIAL	NATIVE	ASTER CHILENSIS	9.25
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	6.18
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA MYUROS	1.07
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	3.78
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1.62
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1.07
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.72
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.54
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	1.07
SHRUBS		NATIVE	BACCHARIS PILULARIS	1.07
SHRUBS		NATIVE	LUPINUS	37.84

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		UNKNOWN	UNKWN SHRUB	1.61

15NOV80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.40
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.40
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	2.05
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.65
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.40
SHRUBS		NATIVE	ARTEMISIA	7.43
SHRUBS		NATIVE	BACCHARIS PILULARIS	0.81
SHRUBS		NATIVE	BERBERIS PINNATA	1.63
SHRUBS		NATIVE	GAULTHERIA SHALLON	4.21
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	30.12
SHRUBS		NATIVE	LUPINUS	28.86
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	1.22
SHRUBS		NATIVE	RUBUS VITIFOLIUS	6.96
SHRUBS		UNKNOWN	UNKWN SHRUB	4.65
TREES		NATIVE	MYRICA CALIFORNICA	7.81
TREES		NATIVE	SALIX HINDSIANA	0.40

28NOV80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.64
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	1.28
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.64
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	4.59
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.93
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.28
FORBS	PERENNIAL	EXOTIC	RUMEX	2.58
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.64
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	0.64
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	1.96
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1.28
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	9.53
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	1.28
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.64
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.93
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	20.54
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	3.24
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	5.27
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	4.59
SHRUBS		NATIVE	LUPINUS	19.04
TREES		EXOTIC	CUPRESSUS SARGENTII	16.53

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15DEC80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	1.60
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	1.60
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1.60
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.80
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.80
FORBS	PERENNIAL	EXOTIC	RUMEX	0.80
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	28.20
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	8.33
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	0.80
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.80
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	13.33
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	11.01
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	14.73
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	2.41
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.41
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	9.21
SHRUBS		NATIVE	LUPINUS	0.80

15DEC80 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
SEAWEED		NATIVE	ULVA	1.07
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	4.40
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.53
FORBS	UNKNOWN	UNKNOWN	HEMIZONIA SP	1.07
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.83
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	2.15
FORBS	PERENNIAL	EXOTIC	RUMEX	0.53
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.15
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	2.15
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.60
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	18.41
SHRUBS		NATIVE	BACCHARIS PILULARIS	6.75
SHRUBS		NATIVE	BERBERIS PINNATA	1.07
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	10.48
SHRUBS		NATIVE	GAULTHERIA SHALLON	10.48
SHRUBS		NATIVE	LONICERA INVOLUCRATA	2.71
SHRUBS		NATIVE	LUPINUS	12.97
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	4.98
SHRUBS		NATIVE	RUBUS VITIFOLIUS	2.15
SHRUBS		UNKNOWN	UNKWN SHRUB	0.53
TREES		EXOTIC	CUPRESSUS SARGENTII	2.15
TREES		NATIVE	MYRICA CALIFORNICA	6.75
TREES		NATIVE	SALIX HINDSIANA	1.07

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15DEC80 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	2.20
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.54
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	6.27
FORBS	UNKNOWN	UNKNOWN	HEMIZONIA SP	1.64
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.54
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.09
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	9.39
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	2.20
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.64
FORBS	PERENNIAL	NATIVE	ERYNGIUM ARMATUM	1.09
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.54
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	2.76
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.73
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	2.76
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	1.09
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.54
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	3.33
SHRUBS		NATIVE	BACCHARIS PILULARIS	3.33
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	10.69
SHRUBS		NATIVE	LUPINUS	19.98
SHRUBS		NATIVE	RUBUS VITIFOLIUS	6.88
SHRUBS		UNKNOWN	UNKWN SHRUB	3.33
TREES		EXOTIC	CUPRESSUS SARGENTII	9.39
TREES		NATIVE	ALNUS SP	2.76
TREES		NATIVE	MYRICA CALIFORNICA	1.09
TREES		NATIVE	SALIX HINDSIANA	2.20

28DEC80 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.52
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.76
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	3.07
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	3.86
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	8.77
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.76
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	3.86
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	8.52
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	47.92
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	3.07
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	6.28
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	4.66
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	3.86
SHRUBS		NATIVE	LUPINUS	0.76
TREES		EXOTIC	CUPRESSUS SARGENTII	2.30

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15JAN81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.31
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	6.01
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	0.65
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3.32
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	28.91
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	0.65
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	1.98
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.31
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.31
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	1.98
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	12.23
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	15.27
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	4.70
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	1.31
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.98
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	1.31
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	6.11
GRASSES/SEDGES	PERENNIAL	NATIVE	STIPA PULCHRA	9.02
SHRUBS		NATIVE	LUPINUS	0.65

15JAN81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	1.17
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	2.36
FORBS	PERENNIAL	EXOTIC	RUMEX	3.60
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	5.97
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	2.37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	9.44
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	1.77
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.17
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.77
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.59
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	2.98
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.59
SHRUBS		NATIVE	ARTEMISIA	19.86
SHRUBS		NATIVE	BACCHARIS PILULARIS	13.69
SHRUBS		NATIVE	LUPINUS	19.08
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	9.44
TREES		NATIVE	MYRICA CALIFORNICA	2.98

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15JAN81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	1.48
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	0.49
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	4.05
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.49
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	2.49
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.48
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	3.00
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.98
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	2.49
FORBS	PERENNIAL	NATIVE	OENOTHERA OVATA	0.98
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	0.98
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.49
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	0.49
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	0.49
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	0.49
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.01
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1.48
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.49
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.49
SHRUBS		NATIVE	ARTEMISIA	10.82
SHRUBS		NATIVE	BACCHARIS PILULARIS	7.88
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	3.52
SHRUBS		NATIVE	LUPINUS	30.80
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	6.76
SHRUBS		NATIVE	RUBUS VITIFOLIUS	6.20
SHRUBS		UNKNOWN	UNKWN SHRUB	0.49
TREES		NATIVE	MYRICA CALIFORNICA	6.20

28JAN81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	1.56
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	3.96
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.56
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	2.35
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	3.96
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	35.64
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.78
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	14.37
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	7.27
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	5.52
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1.56
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	3.15
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	6.43
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	6.43
SHRUBS		NATIVE	ARTEMISIA	0.78
SHRUBS		NATIVE	LUPINUS	0.78
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	2.35

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

TREES		EXOTIC	CUPRESSUS SARGENTII	0.78
TREES		NATIVE	PINUS MURICATA	0.78

15FEB81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	1.29
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.64
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	0.64
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.64
FORBS	PERENNIAL	NATIVE	DENTARIA CALIFORNICA	6.71
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	8.14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	3.27
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	0.64
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	3.27
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	1.94
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	15.01
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	5.31
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	MONERMA CYLINDRICA	1.29
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	5.31
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	31.48
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.60
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.64
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	3.27
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	2.60
TREES		NATIVE	PINUS MURICATA	5.31

15FEB81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	0.47
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.47
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1.88
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.47
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.89
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	14.60
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	10.93
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.46
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	15.89
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	1.89
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	8.09
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.94
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	2.87
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	2.87
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.34
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.47
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	1.41
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.94
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	0.47
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	5.40

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	9.21
SHRUBS		NATIVE	BACCHARIS PILULARIS	2.38
SHRUBS		NATIVE	GAULTHERIA SHALLON	1.41
SHRUBS		NATIVE	LUPINUS	1.41
SHRUBS		NATIVE	MIMULUS AURANTIACUS	1.89
SHRUBS		NATIVE	RUBUS SPP	0.94

15FEB81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	1.18
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.39
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	1.58
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	9.04
FORBS	UNKNOWN	NATIVE	CALANDRINA CILATA	0.78
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.57
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	9.14
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	35.53
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.18
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	2.40
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.39
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	1.99
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.18
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	2.40
GRASSES/SEDGES	PERENNIAL	EXOTIC	PHALARIS TUBEROSA	0.39
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	6.76
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	3.23
SHRUBS		NATIVE	ARTEMISIA	0.78
SHRUBS		NATIVE	BACCHARIS PILULARIS	0.39
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	1.18
SHRUBS		NATIVE	LONICERA SP	4.96
SHRUBS		NATIVE	LUPINUS	11.16

28FEB81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	0.96
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.48
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.45
FORBS	PERENNIAL	NATIVE	DENTARIA CALIFORNICA	1.94
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	0.96
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.96
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS RIGIDUS	5.00
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	25.04
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	0.96
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	8.28
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.45

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	1.94
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	1.94
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	3.96
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	11.67
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	8.84
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	7.16
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	0.96
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.96
GRASSES/SEDGES	PERENNIAL	NATIVE	DESCHAMPSIA CAESPITOSA	5.53
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	0.48
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	7.16
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	1.94

15MAR81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	0.57
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	2.30
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.72
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	19.33
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.57
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	1.14
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	17.76
FORBS	PERENNIAL	NATIVE	DENTARIA CALIFORNICA	4.10
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	1.14
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.14
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.57
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	13.31
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	MONERMA CYLINDRICA	1.72
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	2.30
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	1.72
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	4.71
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	4.10
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.90
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	3.49
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.57
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	7.21
GRASSES/SEDGES	PERENNIAL	NATIVE	CALAMAGROSTIS NUTKAENSIS	0.57
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	1.72
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	5.32

15MAR81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	2.73
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3.91
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	52.92
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	8.88
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	1.33
FORBS	PERENNIAL	EXOTIC	RUMEX	16.96

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.33
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	3.31
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.52
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.52
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.26
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	0.52
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.26
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	0.26
SHRUBS		NATIVE	LUPINUS	5.47
SHRUBS		UNKNOWN	UNKWN SHRUB	0.79

15MAR81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	0.53
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.71
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.35
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.90
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	19.91
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.18
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	68.35
FORBS	PERENNIAL	EXOTIC	RUMEX	0.18
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.65
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.84
FORBS	PERENNIAL	NATIVE	RANUNCULUS CALIFORNICUS	0.18
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.90
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	0.71
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.18
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	0.35
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	0.71
SHRUBS		NATIVE	LUPINUS	0.53
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1.84

15APR81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	2.55
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	1.26
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3.88
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	75.47
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	6.21
FORBS	PERENNIAL	EXOTIC	RUMEX	4.34
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.42
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA MYUROS	0.83
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	0.42
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.83
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2.11
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.68

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15APR81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	1.22
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.48
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.24
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.97
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	40.87
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.24
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	42.24
FORBS	PERENNIAL	EXOTIC	RUMEX	1.73
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.73
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.48
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	1.99
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	2.25
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	HORDEUM LEPORINUM	0.73
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.48
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	0.24
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	0.73
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.48
SHRUBS		NATIVE	LUPINUS	0.48
SHRUBS		NATIVE	RUBUS VITIFOLIUS	0.97
SHRUBS		NATIVE	VACCINIUM OVATUM	0.48
TREES		NATIVE	MYRICA CALIFORNICA	0.97

15APR81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.78
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	3.41
FORBS	ANNUAL/BIENNIAL	EXOTIC	GERANIUM DISSECTUM	0.47
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.62
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.62
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	11.86
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.15
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	70.34
FORBS	PERENNIAL	EXOTIC	RUMEX	0.78
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.66
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	0.15
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.15
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.46
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.62
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	0.31
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.62
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	1.74
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	0.47
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.31
SHRUBS		NATIVE	LUPINUS	2.66
SHRUBS		NATIVE	RUBUS SPP	0.78

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

28APR81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.35
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	8.26
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.80
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	58.17
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.71
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	20.31
FORBS	PERENNIAL	EXOTIC	RUMEX	2.17
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	2.54
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.35
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.14
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.43
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.43
TREES		NATIVE	SALIX HINDSIANA	0.35

15MAY81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
SEAWEED		NATIVE	ULVA	0.30
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	1.22
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.60
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	5.56
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	8.59
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.30
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.30
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	60.93
FORBS	PERENNIAL	EXOTIC	RUMEX	3.48
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.85
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	0.60
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.60
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	3.48
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.30
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	0.91
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	8.49
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	2.17
TREES		NATIVE	SALIX HINDSIANA	0.30

15MAY81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.55
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.28
FORBS	ANNUAL/BIENNIAL	EXOTIC	RAPHANUS SATIVUS	0.55
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	4.14
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	10.58
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	2.25
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.56

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.55
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	44.15
FORBS	PERENNIAL	EXOTIC	RUMEX	1.41
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	3.82
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	0.28
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1.70
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	1.41
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	0.28
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	0.28
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.25
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.84
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM MULTIFLORUM	0.55
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.28
SHRUBS		NATIVE	LUPINUS	17.94
SHRUBS		NATIVE	RUBUS SPP	1.99
SHRUBS		NATIVE	VACCINIUM OVATUM	1.41
SHRUBS		UNKNOWN	UNKWN SHRUB	1.96

15MAY81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	2.69
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	3.92
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.76
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	16.80
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.21
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.21
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	59.21
FORBS	PERENNIAL	EXOTIC	RUMEX	3.17
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.53
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	0.43
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	0.21
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	1.53
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.17
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.43
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	0.21
SHRUBS		NATIVE	LUPINUS	2.69
SHRUBS		NATIVE	MIMULUS AURANTIACUS	1.76
SHRUBS		NATIVE	RUBUS VITIFOLIUS	1.08

15JUN81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	9.13
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	5.97
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	1.50
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	2.27
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	1.12
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.88
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	32.74

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	EXOTIC	RUMEX	3.06
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.67
FORBS	PERENNIAL	NATIVE	CASTILLEJA SP	0.74
FORBS	PERENNIAL	NATIVE	DENTARIA CALIFORNICA	1.12
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	1.12
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.37
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.37
GRASSES/SEDGES		UNKNOWN	CAREX	0.37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	2.67
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AVENA BARBATA	0.74
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BRIZA MAXIMA	0.74
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	2.67
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POLYPOGON MONSPELIENSIS	4.69
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.12
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	13.10
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1.12
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	2.27
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.50
SHRUBS		NATIVE	LONICERA INVOLUCRATA	3.06
SHRUBS		NATIVE	LUPINUS	1.88

15JUN81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.42
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	0.21
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.21
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.21
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.84
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.21
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	72.58
FORBS	PERENNIAL	EXOTIC	RUMEX	12.37
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.18
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	2.41
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.21
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.21
SHRUBS		NATIVE	LONICERA HISPIDULA	0.21
SHRUBS		NATIVE	LUPINUS	1.73
SHRUBS		NATIVE	SAMBUCUS	3.12
TREES		NATIVE	SALIX HINDSIANA	2.88

15JUN81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.25
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.25
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.25
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.76
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.50
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.50

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	62.57
FORBS	PERENNIAL	EXOTIC	RUMEX	0.25
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.50
FORBS	PERENNIAL	NATIVE	BRODIAEA LAXA	0.50
FORBS	PERENNIAL	NATIVE	PRUNELLA VULGARIS	0.25
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	1.80
GRASSES/SEDGES	UNKNOWN	UNKNOWN	BROMUS SPP	0.50
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.53
SHRUBS		NATIVE	LONICERA HISPIDULA	10.29
SHRUBS		NATIVE	LUPINUS	3.17
SHRUBS		NATIVE	MIMULUS AURANTIACUS	2.07
SHRUBS		NATIVE	SAMBUCUS CALLICARPA	11.45
TREES		NATIVE	SALIX HINDSIANA	2.61

28JUN81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	2.72
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	1.34
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	13.81
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	5.61
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1.34
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	55.85
FORBS	PERENNIAL	EXOTIC	RUMEX	3.19
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	0.89
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.79
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.44
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.06
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.89
SHRUBS		NATIVE	LONICERA HISPIDULA	1.34
SHRUBS		NATIVE	LONICERA INVOLUCRATA	1.79
SHRUBS		NATIVE	LUPINUS	2.25
TREES		NATIVE	SALIX HINDSIANA	2.72

15JUL81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
SEAWEED		NATIVE	ULVA	0.62
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.62
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	1.25
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM	0.62
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	7.89
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	4.48
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	5.82
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.62
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.62
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	3.82
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	30.53
FORBS	PERENNIAL	EXOTIC	RUMEX	10.04
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.88

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.17
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	4.48
FORBS	PERENNIAL	NATIVE	SISYRINCHIUM BELLUM	0.62
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	MONERMA CYLINDRICA	0.62
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	1.88
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	4.48
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	1.88
GRASSES/SEDGES	PERENNIAL	NATIVE	DISTICHLIS SPICATA	0.62
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	4.48
GRASSES/SEDGES	PERENNIAL	NATIVE	HORDEUM BRACHYANTHERUM	1.25
SHRUBS		NATIVE	LONICERA HISPIDULA	4.48
TREES		NATIVE	SALIX HINDSIANA	3.17

15JUL81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	1.42
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.23
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1.66
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.18
FORBS	PERENNIAL	EXOTIC	ANAPHALIS MARGARITACEA	0.70
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.93
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	52.75
FORBS	PERENNIAL	EXOTIC	RUMEX	24.71
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	4.55
FORBS	PERENNIAL	NATIVE	MIMULUS GUTTATUS	2.41
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	0.23
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.42
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.46
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.23
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.23
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	2.16
SHRUBS		NATIVE	LUPINUS	0.70
SHRUBS		NATIVE	RUBUS VITIFOLIUS	0.70
SHRUBS		NATIVE	SAMBUCUS	0.46
SHRUBS		UNKNOWN	UNKWN SHRUB	0.70
TREES		NATIVE	SALIX HINDSIANA	2.16

15JUL81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	0.22
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	0.22
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.22
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.22
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.22
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.68
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.45
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	40.62
FORBS	PERENNIAL	EXOTIC	RUMEX	16.27

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	7.59
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	1.37
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	0.22
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	3.77
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	0.45
SHRUBS		NATIVE	ARTEMISIA	0.45
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.22
SHRUBS		NATIVE	LUPINUS	2.34
SHRUBS		NATIVE	RUBUS SPP	20.31
SHRUBS		NATIVE	SAMBUCUS	1.61
TREES		NATIVE	MYRICA CALIFORNICA	0.45
TREES		NATIVE	SALIX HINDSIANA	2.09

28JUL81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	1.26
FORBS	ANNUAL/BIENNIAL	EXOTIC	ERODIUM CICUTARIUM	7.28
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	3.21
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	7.28
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	3.21
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.63
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.26
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.63
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.26
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	31.92
FORBS	PERENNIAL	EXOTIC	RUMEX	7.99
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.26
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1.26
FORBS	PERENNIAL	NATIVE	IRIS DOUGLASIANA	0.63
FORBS	PERENNIAL	NATIVE	MIMULUS SP	2.55
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	2.55
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	3.21
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	1.91
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	1.91
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	7.28
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	3.87
SHRUBS		NATIVE	LONICERA HISPIDULA	1.91
SHRUBS		NATIVE	LUPINUS	0.63
SHRUBS		NATIVE	SAMBUCUS CALLICARPA	3.21
TREES		NATIVE	SALIX HINDSIANA	1.91

15AUG81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS		NATIVE	POLYSTICHUM MUNITUM	0.48
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.97
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	1.46
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.48
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.97

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	2.45
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	2.45
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.95
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	15.06
FORBS	PERENNIAL	EXOTIC	RUMEX ACETOSELLA	6.67
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	2.45
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.46
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	4.51
FORBS	PERENNIAL	NATIVE	POTENTILLA SP	8.34
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	AIRA CARYOPHYLLEA	4.51
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	0.48
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	2.45
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	0.97
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	2.96
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	2.96
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	15.06
GRASSES/SEDGES	PERENNIAL	NATIVE	AGROSTIS DIEGOENSIS	0.97
SHRUBS		NATIVE	ARTEMISIA	0.48
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	0.97
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.97
SHRUBS		NATIVE	LONICERA HISPIDULA	0.48
SHRUBS		NATIVE	LUPINUS	3.99
SHRUBS		NATIVE	RHAMNUS CALIFORNICA	0.48
SHRUBS		NATIVE	RUBUS VITIFOLIUS	2.96
SHRUBS		UNKNOWN	UNKWN SHRUB	7.05
TREES		NATIVE	MYRICA CALIFORNICA	0.48
TREES		NATIVE	SALIX HINDSIANA	1.95

15AUG81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
LOWER PLANTS	UNKNOWN	UNKNOWN	UNKNWN FERN	0.39
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.39
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.39
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	0.78
FORBS	ANNUAL/BIENNIAL	EXOTIC	SPERGULA ARVENSIS	1.57
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.39
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	0.78
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.17
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.39
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.39
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	18.99
FORBS	PERENNIAL	EXOTIC	RUMEX	5.79
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	22.27
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.54
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	6.24
FORBS	PERENNIAL	NATIVE	MIMULUS SP	0.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	0.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.39
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	0.39
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	0.39
SHRUBS		NATIVE	ARTEMISIA	5.35

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	7.62
SHRUBS		NATIVE	LONICERA HISPIDULA	1.17
SHRUBS		NATIVE	LUPINUS	5.79
SHRUBS		NATIVE	RHUS DIVERSILOBA	0.78
SHRUBS		NATIVE	RUBUS SPP	0.39
SHRUBS		UNKNOWN	UNKWN SHRUB	0.39
TREES		NATIVE	MYRICA CALIFORNICA	0.78
TREES		NATIVE	SALIX HINDSIANA	5.35

15AUG81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.34
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	1.01
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	2.37
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	0.67
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	0.34
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	20.48
FORBS	PERENNIAL	EXOTIC	RUMEX	4.25
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	28.05
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.81
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	7.00
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	FESTUCA DERTONENSIS	1.01
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKWN GRASS1	2.06
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.01
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	0.34
SHRUBS		NATIVE	ARTEMISIA	6.60
SHRUBS		NATIVE	BERBERIS PINNATA	0.34
SHRUBS		NATIVE	GAULTHERIA SHALLON	0.34
SHRUBS		NATIVE	HETEROMELES ARBUTIFOLIA	0.34
SHRUBS		NATIVE	LUPINUS	6.60
SHRUBS		NATIVE	RUBUS VITIFOLIUS	2.06
TREES		EXOTIC	CUPRESSUS SARGENTII	0.67
TREES		NATIVE	SALIX HINDSIANA	0.34

28AUG81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	CARDUUS TENUIFLORUS	0.53
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	0.53
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	15.75
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	2.13
FORBS	UNKNOWN	UNKNOWN	UNKWN LEGUME	0.53
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.53
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	1.60
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	13.00
FORBS	PERENNIAL	EXOTIC	RUMEX	0.53
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	6.10
FORBS	PERENNIAL	NATIVE	HYPOCHOERIS RADICATA	1.60
FORBS	PERENNIAL	NATIVE	MIMULUS SP	4.36

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEI	1.06
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	POA ANNUA	1.60
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.53
GRASSES/SEDGES	UNKNOWN	UNKNOWN	FESTUCA SP	1.60
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.60
GRASSES/SEDGES	UNKNOWN	UNKNOWN	HORDEUM SP	6.69
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	24.17
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	2.13
GRASSES/SEDGES	PERENNIAL	EXOTIC	PHALARIS TUBEROSA	0.53
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	5.51
GRASSES/SEDGES	PERENNIAL	NATIVE	DANTHONIA CALIFORNICA	0.53
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.60
SHRUBS		NATIVE	ARTEMISIA	1.06
SHRUBS		NATIVE	CEANOTHUS THRYSIFLORUS	1.06
SHRUBS		NATIVE	LUPINUS	1.06
TREES		EXOTIC	CUPRESSUS SARGENTII	1.06
TREES		NATIVE	MYRICA CALIFORNICA	0.53
TREES		NATIVE	SALIX HINDSIANA	0.53

15SEP81 TULE ELK

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	SILENE GALLICA	0.52
FORBS	ANNUAL/BIENNIAL	EXOTIC	SPERGULA ARVENSIS	1.58
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	1.05
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	10.92
FORBS	UNKNOWN	UNKNOWN	CIRSIUM SP	1.05
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	3.59
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	12.88
FORBS	PERENNIAL	EXOTIC	LOBULARIA MARITIMA	3.76
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	10.92
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	1.58
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.58
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	1.05
FORBS	PERENNIAL	NATIVE	MIMULUS SP	1.58
GRASSES/SEDGES	ANNUAL/BIENNIAL	EXOTIC	BROMUS MOLLIS	17.02
GRASSES/SEDGES	UNKNOWN	NATIVE	JUNCUS SPP	0.52
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	1.05
GRASSES/SEDGES	PERENNIAL	EXOTIC	HOLCUS LANATUS	16.31
GRASSES/SEDGES	PERENNIAL	EXOTIC	LOLIUM PERENNE	6.62
GRASSES/SEDGES	PERENNIAL	NATIVE	BROMUS MARGINATUS	1.58
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	1.58
SHRUBS		NATIVE	LONICERA HISPIDULA	1.58
SHRUBS		NATIVE	LUPINUS	0.52
SHRUBS		NATIVE	RUBUS SPP	0.52
TREES		NATIVE	SALIX HINDSIANA	0.52

DIET BY SAMPLE PERIOD OF TULE ELK AND BLACK-TAILED DEER

15SEP81 BLACK-TAILED DEER LOCATION=NORTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	ANAGALLIS ARVENSIS	0.80
FORBS	ANNUAL/BIENNIAL	NATIVE	LAYIA PLATYGLOSSA	1.63
FORBS	ANNUAL/BIENNIAL	NATIVE	MONTIA PERFOLIATA	27.61
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	2.04
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	0.40
FORBS	PERENNIAL	EXOTIC	COTULA CORONOPIFOLIA	1.21
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	30.93
FORBS	PERENNIAL	EXOTIC	RUMEX	8.89
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	11.99
FORBS	PERENNIAL	NATIVE	HYDROCOTYLE RANUNCULOIDES	0.80
GRASSES/SEDGES	UNKNOWN	UNKNOWN	UNKNWN GRASSES	0.40
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	2.89
SHRUBS		NATIVE	LUPINUS	3.32
SHRUBS		NATIVE	RUBUS VITIFOLIUS	3.76
TREES		NATIVE	SALIX HINDSIANA	3.32

15SEP81 BLACK-TAILED DEER LOCATION=SOUTH

PLANT TYPE	GROWTH	STATUS	SPECIES	PERCENT
FORBS	ANNUAL/BIENNIAL	EXOTIC	SISYMBRIUM OFFICINALE	0.37
FORBS	ANNUAL/BIENNIAL	EXOTIC	SPERGULA ARVENSIS	4.28
FORBS	UNKNOWN	NATIVE	STACHYS SP	1.12
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB	0.37
FORBS	UNKNOWN	UNKNOWN	UNKWN FORB1	1.11
FORBS	PERENNIAL	EXOTIC	ANAPHALIS MARGARITACEA	3.88
FORBS	PERENNIAL	EXOTIC	PLANTAGO LANCEOLATA	24.04
FORBS	PERENNIAL	NATIVE	ACHILLEA BOREALIS	10.09
FORBS	PERENNIAL	NATIVE	ERIOGONUM LATIFOLIUM NUDUM	0.30
FORBS	PERENNIAL	NATIVE	POTENTILLA EGEDEI	2.28
GRASSES/SEDGES	PERENNIAL	NATIVE	FESTUCA RUBRA	0.74
GRASSES/SEDGES	PERENNIAL	NATIVE	HIEROCHLOE OCCIDENTALIS	1.12
SHRUBS		NATIVE	ARTEMISIA CALIFORNICA	31.89
SHRUBS		NATIVE	LUPINUS	6.85
SHRUBS		NATIVE	RUBUS VITIFOLIUS	2.28
TREES		NATIVE	SALIX HINDSIANA	2.28

POPULATION DYNAMICS OF TULE ELK AT POINT REYES NATIONAL SEASHORE, CALIFORNIA

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Abstract: The presence of locally abundant wildlife raises questions about natural regulation and ecological consequences of overpopulation. We sought to establish precise information about population size, structure, and productivity to examine the role of natural regulation in a closed tule elk (*Cervus elaphus nannodes*) population at Point Reyes National Seashore, California, USA. We estimated an instantaneous exponential growth rate of 0.19 with an adjusted $R^2 = 0.98$ during 1998, 20 years after the elk were introduced. We estimated annual survival for adult cows of nearly 0.95. Calf survival from birth through the rut ending during October–November was 0.85. Male calves exhibited higher mortality than female calves. Cow mortality was associated with the calving season. We measured a 42% increase in cow:calf density from 0.733 ha^{-1} to 1.043 ha^{-1} during 1996–1998. We observed a density-correlated reduction in the rate of increase and in the cow:calf ratios prior to high precipitation El Niño Southern Oscillation years, 1993, 1996, and 1997, precipitation >1.23 m year^{-1}. Given the high population growth rate and model evaluation of management scenarios, park managers will need to use a suite of approaches, such as contraception and removal, to maintain the elk population at levels at or near the closed-range carrying capacity for years between El Niño events.

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Key words: California, *Cervus elaphus nannodes*, demographics, El Niño, National Parks, natural regulation, populations, reproduction, tule elk.

Tule elk are a subspecies of elk isolated from other populations during the Wisconsin glacial period, and are endemic to California (Bryant and Maser 1982). Once abundant in the state, tule elk were driven to near extinction by the last quarter of the 19th century when only 6–10 individuals remained on a private ranch in the San Joaquin Valley (McCullough 1969). Early conservation and reintroduction efforts during the latter half of the 20th century have resulted in a statewide recovery of tule elk populations to an estimated 3,500 animals (J. Fischer, California Department of Fish and Game, personal communication).

During March 1978, 10 adult elk (2 males and 8 females) were reintroduced to Point Reyes National Seashore (NS) from the San Luis National Wildlife Refuge (Gogan 1986). The elk were placed on a 1,052-ha enclosed range on the northern tip of Tomales Point (Fig. 1). Prior to the complete removal of beef cattle during 1980, the range was characterized by high stocking rates of cattle and low forage quality (Gogan 1986). During the initial period of 1978–1980, the elk herd did not grow and was constrained by trace element deficiency, infection with Johne's disease (*Mycobacterium paratuberculosis*) that lowered subadult survival, and low reproductive rates (Gogan 1986). After the removal of cattle during 1980, the population began to increase (Gogan and Barrett 1987). Early research on vegetation estimated that the habitat could support between 140 and 350 elk with cattle still present or recently removed (Gogan 1986). By 1990, the elk herd had reached the lower bounds of that estimate, and by 1993 had reached an estimated 214 individuals (Wahome 1995). Although public hunting of the herd may be permitted at Point Reyes NS through its enabling legislation, public testimony before the Citizens' Advisory Commission (CAC) to Point Reyes NS strongly opposed hunting in the park.

In response to increasing numbers of elk, the National Park Service (NPS) commissioned an advisory panel of 6 scientists to examine available elk data and to recommend actions for NPS management of the tule elk herd (McCullough et al. 1993). McCullough (1992:969) defined K selected species carrying capacity (KCC) as the "maximum

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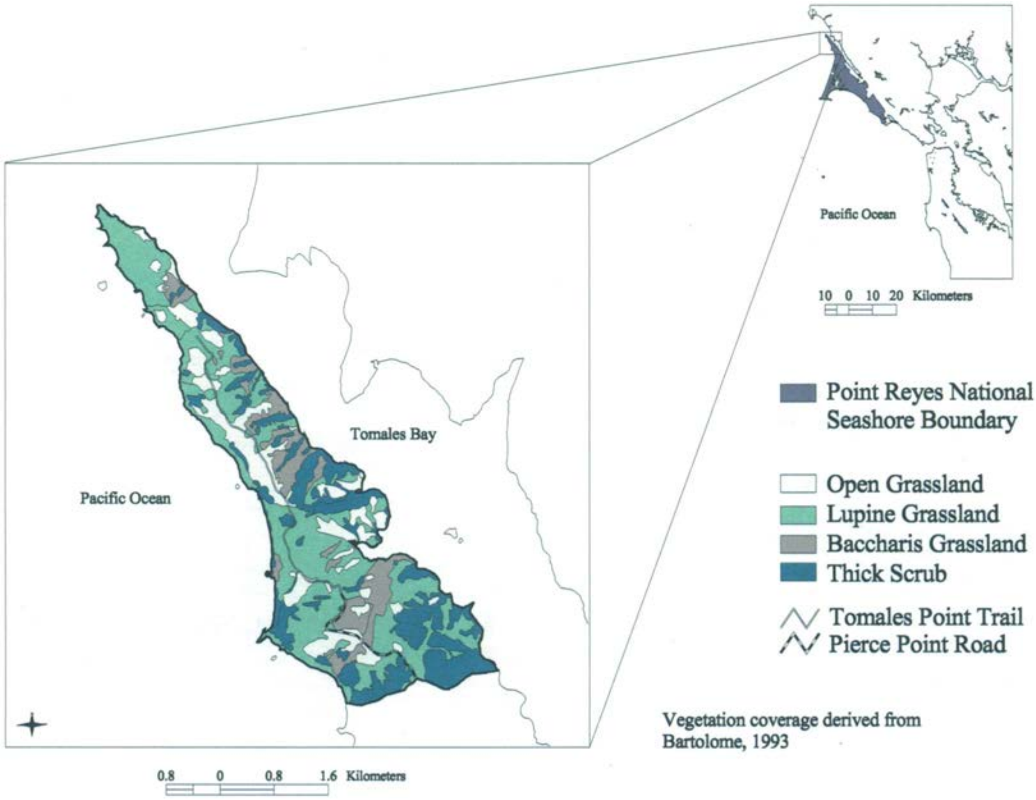

Fig. 1. Tule elk range, Tomales Point, Point Reyes National Seashore, California, USA.

number of animals of a given population supportable by the resources of a specified area." The panel estimated KCC at approximately 350 elk, assuming density-dependent population regulation (McCullough et al. 1993). In addition, the panel recommended (1) permitting the elk population to self-regulate unless a predefined threshold of ecological damage to the range was reached, (2) establishing a pilot study to assess the feasibility of utilizing contraceptives as a means of population control, (3) beginning a program of fecal culture and necropsy to establish the status of Johne's disease and potentially other livestock diseases, (4) expanding the habitat and elk population monitoring program, (5) importing 2–3 female elk every generation, and (6) reestablishing free-ranging elk on other NPS lands. This study was designed to address part 4 of the research recommendations offered by the scientific panel (McCullough et al. 1993) and to assist in maintaining a viable herd of tule elk at Point Reyes NS (National Park Service 1988, 1992). During 1997, park managers decided to conduct contraception trials on a subset of the Tomales Point herd. Thirty cows were captured and inoculated with porcine zona pellucida (PZP; Stoops et al. 1999; Shideler et al., in press).

Precise measures of population size, structure, and productivity are necessary to develop accurate estimates of population growth. Accurate estimates of population growth and habitat use are critical for defining the bounds of KCC for the Tomales Point elk herd. If density-dependent factors are controlling this population, we would expect the net reproductive rate of the population in a year (λ) to approach unity ($\lambda = 1$) and the intrinsic rate of increase (r) to approach zero (r = 0) as the population approaches KCC for a given resource state. We define population growth as:

$$N_t = rN_{t-1}, \quad (1)$$

where $r = dN/dt$, N is the population size, and t is time in years. If λ remains above 1, the population will overshoot KCC with potentially negative

impacts to elk habitat. Refined estimates should indicate whether density-related mechanisms are operating as this herd approaches KCC.

Here, we examine the population size, structure, and productivity of the Point Reyes NS tule elk herd relative to its potential natural regulation (Houston 1982). We report the age-specific mortality, cow:calf ratios, natality rate, sex ratios, and population density 20 years after initial introduction of tule elk on Point Reyes NS.

STUDY AREA

Point Reyes NS is a 28,827-ha national park located 60 km northwest of San Francisco, California (Fig. 1). The elk are confined to the northern tip of Tomales Point, a northwest-trending peninsula bounded by a 3-m-tall fence on the east by Tomales Bay and on the west by the Pacific Ocean. The fence separates the 1,052-ha range from an active dairy ranch to the south.

The elk range can be classified into 4 habitat types: open grassland (supporting both annual and perennial grasses and forbs), lupine (*Lupinus arboreus*) grassland, coyotebush (*Baccharis pilularis*) grassland, and dense scrub (Fig. 1). Three federally listed rare plant species occur locally: Point Reyes blennosperma (*Blennosperma nanum* var. *robustum*), North Coast bird's beak (*Cordylanthus maritimus* ssp. *palustris*), and San Francisco owl's clover (*Triphysaria floribunda*). In addition, the Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*), a federally listed endangered species, occurs within the elk range. Three larger predators have been observed on the elk range: coyote (*Canis latrans*), bobcat (*Felis rufus*), and mountain lion (*Puma concolor*).

The climate of the elk range is Mediterranean, with most rainfall occurring between November and March. Annual precipitation totals fluctuate considerably between wet and dry years. Between 1978 and 1996, average precipitation 16 km due north of Tomales Point at Bodega Marine Laboratory was 853.3 mm (SE = 75.9, $n = 19$; V. Chow, University of California at Davis, personal communication). However, average precipitation for wetter-than-normal El Niño events, 1982–1984 and 1995–1997, was 1,364.4 mm (SE = 110, $n = 4$). The average temperature varies between 7 °C during the winter and 13 °C during the summer.

METHODS

Capture Techniques

Adult female elk were captured during November 1995 and October 1996 with helicopter-deployed ballistic nets (Helicopter Wildlife Management, Salt Lake City, Utah, USA). Elk were blindfolded and hobbled upon capture. Processing teams measured total length and girth, monitored vital functions, estimated animal age by examining teeth and body size, and collected blood and fecal samples to determine pregnancy rates and screen for Johne's disease. Blood and fecal samples were transported to Madison, Wisconsin, for Johne's disease testing and to the University of California at Davis for pregnancy testing (Stoops et al. 1999; Shideler et al., in press). A color-coded radio-collar (Telonics, Mesa, Arizona, USA), with a mortality sensor and a breakaway device, was attached to each cow. The breakaway device had a field life of 7 to 10 years based on studies of elk in Redwood National Park (R. Golightly, Humboldt State University, personal communication). Radio-collar transmissions were set for alternate days to extend the expected transmitter life to 7 years from the time of attachment to the elk.

Researchers, on foot or horseback, captured calves during spring (Mar–Jun) of 1996, 1997, and 1998. Cows were approached by horseback and were observed looking in the direction of potential calf bedding areas. Potential calf bedding areas were searched in a back-and-forth pattern. Once located, bedded calves were approached on foot and captured by hand by placing a blindfold or hat over their eyes. All calves were weighed, measured, and fitted with color-coded ear tags to identify individuals. During 1996, calves were fitted with solar-powered radio ear tags (Advanced Telemetry Systems, Isanti, Minnesota, USA). This practice was discontinued during 1997 because the transmitters were lost as a result of grooming behavior. During all years, calf mortality was determined by assuming that color-marked and radio-marked calves not seen for 2 weeks had died.

Herd Size and Structure

We monitored the elk population weekly from 1995 to 1998 by visual observation from horseback of both marked and unmarked individuals. The elk range was searched for groups of elk from highlands until the entire range was explored. In the field, locations for each radio-marked female and tagged calf were marked on USGS 7.5-min topographic quadrangle sheets and/or field notes. For each relocation point, we recorded data about habitat, behavior, and herd composition classes of adult cows, calves, spike bulls, bulls, and prime bulls. Universal Transverse Mercator (UTM) coordinates for relocation

points were determined by analysis of the field maps and notes and digitized using AutoCAD LT 98 (Autodesk, San Rafael, California, USA) and ArcView 3.1 (Environmental Systems Research Institute, Redlands, California, USA).

During October 1996, after the rut, simultaneous aerial and ground counts of the entire herd were conducted to determine the number of cows, calves, spike bulls, and bulls using fixed-wing aircraft censuses, drive counts, and herd structure counts (McCullough 1997). We conducted herd structure counts from horseback over several days. In addition, we counted calves during the summer and fall of each year to measure productivity. Natality of each radiomarked cow and the survival of her marked calf were recorded for each year of the study to determine whether the cow had reared a calf to maturity—i.e., until after the rut during October. Production of female offspring was estimated from the annual calf searches. During 1997, we conducted weekly horseback surveys of bulls on the entire elk range. Surveys were conducted intermittently during 1998.

Estimates of population size from year to year provided a basis for calculating population growth and the foundation for demographic projections such as estimating KCC. To estimate *r*, we used the average of dN/dt for all years. To derive a second estimate of *r*, we used SPSS 8.0, a statistical curve-fitting program (Norusis 1988*a*,*b*). The age and sex structure of the herd was modeled using original data for the introduced herd (Gogan 1986) as a baseline. We calculated number of calves surviving each year (t) by subtracting the previous year total population (N_{t-1}) from the current year total population (N_t). We divided the number of calves by 2 to determine the number of female calves. If there was a remainder, we added 1 to the number of female calves for that year, assuming a slightly higher mortality among male calves. This provided our sex-ratio estimate. We began the model with data from 1984 and extrapolated through 1998.

Mortality and Survival

During 1996, we conducted systematic mortality searches in 3 areas of high herd use: grassland and moderate to dense coastal scrub of 38, 35, and 40 ha, respectively. We systematically searched each area with 7 people evenly spaced across the width of the search area and walked a zigzag pattern to maximize coverage. We subsequently discontinued this practice because we recovered few elk remains and the mortality rates within the herd were low. Since most of the range was covered by horseback on a biweekly basis, we substituted opportunistic discovery of remains for the systematic ground searches. Records were kept of known instances of mortality from both the radiomarked and general population. If an individual disappeared between sequential ground counts, we compared the result with mortality records to infer mortality dates.

We estimated mortality or, conversely, survival rates of females from the radiomarked sample 2 ways: first, by pooling all years; second, by taking the mean of each year's proportional mortality to derive 2 linear survival rates. We also estimated a third survival curve from cows ear tagged during the first introductions or as calves born through 1981 and observed in subsequent field surveys.

Density

We monitored the location, habitat use, and survival of the remaining 34 radiomarked cow elk and 66 tagged calves through December 1998. We located radiomarked cows at dawn, dusk, and night. We used the relocation points to estimate herd range size using the adaptive kernel method (50% and 90% isopleths; TELEM 1.0, U.S. Forest Service; Worton 1989). We used relocation data from the first year of the study to calculate individual home ranges for all radiomarked cows. We randomly selected a subset of the individual relocations to establish herd range size and found no difference in herd range size between the random subset of relocation points ($n = 20$/elk) and all the relocation points. By visual inspection, 2 patterns became clear: individuals clustered in the northern or southern part of the range. We examined individual movements and found virtually no exchange among individuals between north and south during 1995 and 1996. During subsequent years, 2 individuals switched groups while 3 more cows made 1 excursion and returned. Although the individuals may move randomly within a herd, we assumed that the 2 subherds were geographically stable. We used 4,229,000 UTM North as the cutoff line between the 2 subherds. This UTM coordinate corresponded to the middle of the high plateau between the more varied relief to the north and south. We pooled the relocation records for all individuals in a subherd by season to estimate herd range size and calculate high and low habitat-use areas. We estimated population density for each year by using the number of animals seen in the subherd and calculating mean herd range size at the 90% isopleth across 4 bio-

logical seasons—calving (Apr and May), summer (Jun and Jul), the rut (Aug–Oct), and winter (Nov–Mar). During 1997, we conducted weekly surveys of bulls on the entire elk range. Location, numbers, and age composition of the groups were recorded. We did not record individual bulls but used group and solitary animal locations to establish relocation points. Cow relocation data and bull count data were considered independent, and cow and bull range use were mapped separately.

Herd Growth Stabilization Modeling

Greene et al. (1998) developed a breeding system-based model to model population growth rates under different management scenarios. Assumptions of the model were (1) equivalence of individuals (all individuals of a given age–sex class were equally likely to reproduce or die), (2) population processes were density-independent (there was no carrying capacity or other source of regulation), (3) population processes do not depend on population spatial structure, and (4) reproduction occurs after mortality for ease of computation. We used our empirically derived population parameters to drive Greene's model to examine the relationship and effectiveness of removal and/or contraception (Shideler et al., in press) rates to reduce the net reproductive rate of the Tomales Point herd to zero.

Statistical Analyses

For comparisons, we performed Pearson's Chi-square (χ^2) test of significance ($P <$ –0.05; Lehmann 1975; Norusis 1988*a*,*b*).

RESULTS

We captured 20 adult female elk during November 1995 and 18 during October 1996. The day after the first capture, 1 cow died from capture myopathy, leaving 19 radiomarked cows during 1995. Blood samples from these 19 cows revealed that 16 were pregnant (Stoops et al. 1999). Three cows captured during 1995 died during the 1996 calving season. During 1996, 1997, and 1998, we captured 12, 26, and 28 calves, respectively. Sixteen of the 66 color and radiomarked calves were born to radiomarked cows over the 3-year period. While most calving consistently occurred during April and May, births were documented as early as February and as late as August.

Herd Size and Composition

The total population counts for 1996, 1997, and 1998 were 370, 465, and 549, respectively. During 1996, total counts by horseback, ground, and airplane were within a range of 15 animals (Table 1). The annual rates of population increase (r) in our study for 1996 through 1998 were 0.32, 0.26, and 0.19. The 1998 calf count of 87 was lower than the expected 120 calves. This may have been caused by the inoculation of 30 cows contracepted with PZP during fall 1997 (Shideler et al., in press). For 1981 through 1997, mean r was 0.22 (SE = 0.022, n = 17, Min. = 0.08, Max. = 0.41). An exponential

Table 1. Herd composition counts of tule elk using aerial counts, drive counts, and horseback search counts, Point Reyes National Seashore, California, USA, 1996–1998.

Year	Category	Method: Aerial	Drive	Horseback
1996	Bull	91	72	90
	Spike	4	10	19[a]
	Cow	222	253	179
	Calf	66	46	80
	Total	385	381	370
1997	Bull		110	122
	Spike		71	48
	Cow		240	218
	Calf		42	77
	Total		465	465
1998	Bull			161[b]
	Spike			45[c]
	Cow			256
	Calf			87
	Total			549

[a] Estimated as a subset of total bull counts.
[b] Estimated from spring bull counts.
[c] Estimated from number of calves born the previous year.

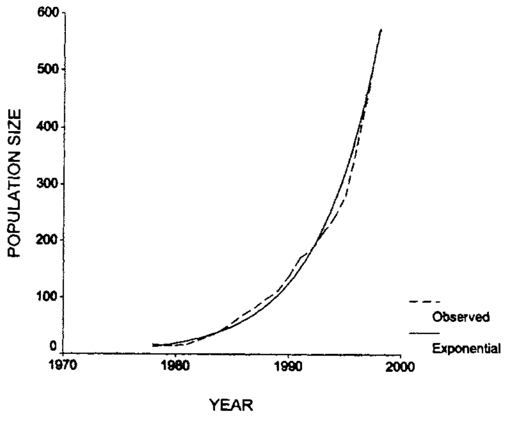

Fig. 2. Tule elk population growth, observed vs. exponential model, 1978–1997, Point Reyes National Seashore, California, USA.

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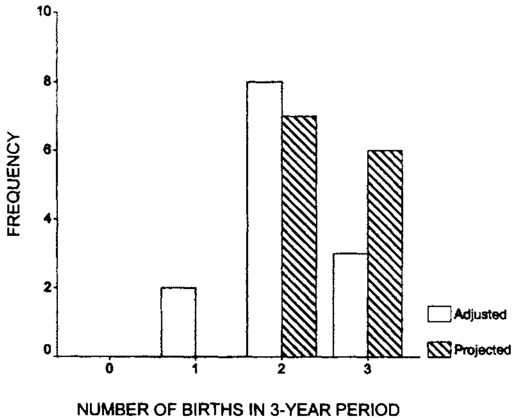

Fig. 3. Number of elk calf births to radiomarked cows that survived the 3 years of this study, 1996–1998, Point Reyes National Seashore, California, USA. (Adjusted conservatively based on field observation. Projected from field observations.)

model provided the best fit to the observed data (r = 0.1943, R^2 = 0.984) for 1981 through 1997 (Fig. 2). Thirteen of the 16 radiomarked cows that survived for 3 years had at least 1 calf with an average of 2.076 calves female^{-1} (Fig. 3).

Using linear regression, we detected no significant reduction in population growth rate with increasing population size through 1997 (Fig. 4A). If we removed the high productivity El Niño years of 1983, 1993, 1996, and 1997, when precipitation was >1.024 m yr^{-1}, we found a significant negative linear relationship for rate of population change (P = 0.025, R^2 = 0.447; Fig. 4B). If the dry-year declining rate of growth was constant, the intercept of the abscissa for r = 0 would be approximately 360 animals by the year 2000. A quadratic model best described the decline in cow:calf ratios with population size during dry years be-

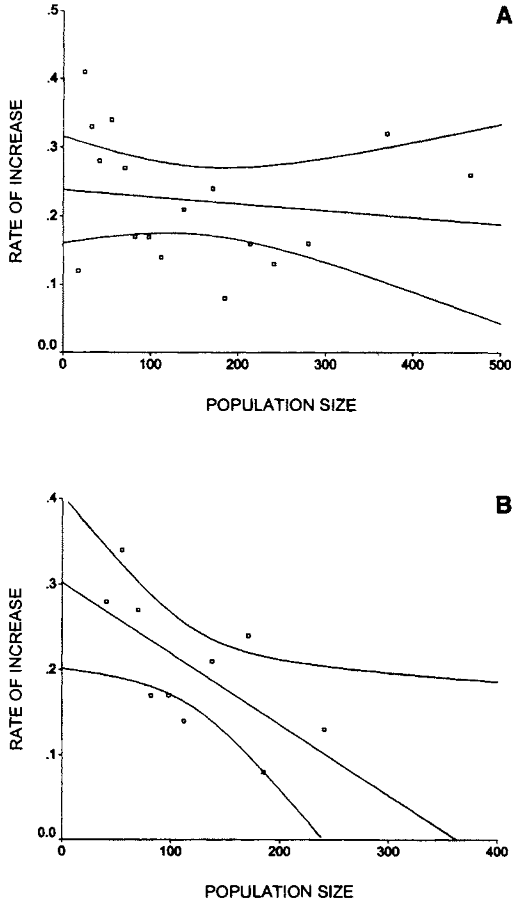

Fig. 4. Tule elk population growth rate vs. population size, 1980–1997. (A) Including El Niño years. (B) Excluding El Niño years.

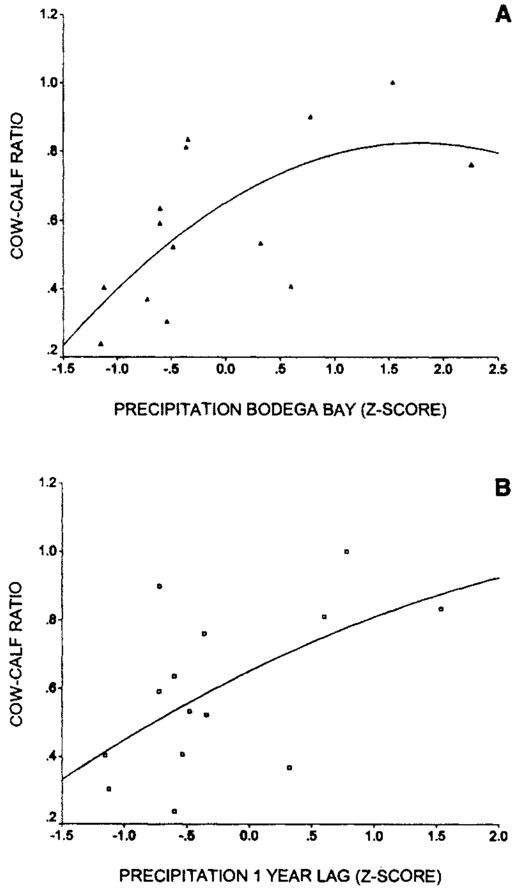

Fig. 5. Tule elk cow:calf ratios vs. annual precipitation, 1980–1997. (A) Current year precipitation. (B) Previous year precipitation. Precipitation data from University of California, Bodega Marine Laboratory, Bodega Bay, USA.

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Table 2. Coefficients for multiple regression of cow:calf ratio vs. precipitation during current year and 1-year time lag from 1984 to 1997, at Bodega Bay, California, USA.

	Unstandardized coefficients		Standardized coefficients		
Model	B	SE	Beta	T	Significance
Constant	0.633	0.047		13.582	0.000
Current year precipitation	0.125	0.047	0.527	2.684	0.021
Precipitation lagged 1 year	0.146	0.061	0.472	2.407	0.035

tween El Niño years (P = 0.000, R^2 = 0.768, N = 112.263 – 0.656x + 0.014x^2; Fig 5A). The proportion of calves per 100 cows was positively correlated with precipitation for any given year (t) and the prior year (t – 1; Fig. 5B). A multiple regression model for the proportion of calves per 100 cows and the 2 precipitation parameters was highly significant (Table 2).

The outcome of the herd-composition model predicted 9.6% more adult bulls and 7.7% fewer adult cows than observed during herd counts (Table 3). The observed herd counts for 1997 and 1998 were not significantly different from the estimated herd structures using a Chi-square test.

Mortality and Survival

During the 1996 systematic mortality searches of 113 ha, we discovered the remains of 2 cows. We divided the total area of the elk range (1,052 ha) by area sampled (113 ha) and multiplied the number of carcasses discovered (2) to estimate that 18 elk had died across the range. During our opportunistic recoveries between 1995 and 1998, we collected 15 specimens, and we constructed a simple a posteriori life histogram for the herd (Fig. 6).

During 1996, 3 radiomarked cows died during the spring calving season. No symptoms of Johne's disease, wasting, or diarrhea were evident.

Table 3. Tule elk herd composition, Point Reyes National Seashore, California, USA, 1980–1998.

		Observed[a,b]			Expected[c]		
Year	N	Calf	Bull	Cow	Calf	Bull	Cow
1980	15	1	4	10	1	4	10
1981	18	6	4	8	6	4	8
1982	24	8	6	10	8	6	10
1983	32	8	10	14	8	10	14
1984	41	9	–[d]	–	9	14	18
1985	55	15	–	–	14	18	23
1986	70	16	–	–	15	25	30
1987	82	19	–	–	12	32	38
1988	98	–	–	–	16	38	44
1989	112	–	–	–	14	46	52
1990	138	23	38	75	26	53	59
1991	171	34	65	82	33	66	72
1992	185	33	79	90	14	82	89
1993	214		65	98	29	89	96
1994	241	32	93	127	27	103	111
1995	280	19	73	157	39	116	125
1996	370	80	109	179	90	135	145
1997	465	77	170	218	95	180	190
1998	549	87	206	256	87	227	238

[a] Numbers observed during fall herd count.
[b] Observed by P. J. P. Gogan, 1980–1987; O. L. Wallis, 1990, 1992, 1993; L. George, 1994; and S. Koening, 1995. High calf numbers reflect spring counts.
[c] Numbers extrapolated from fall herd counts and prior year estimates.
[d] No data available.

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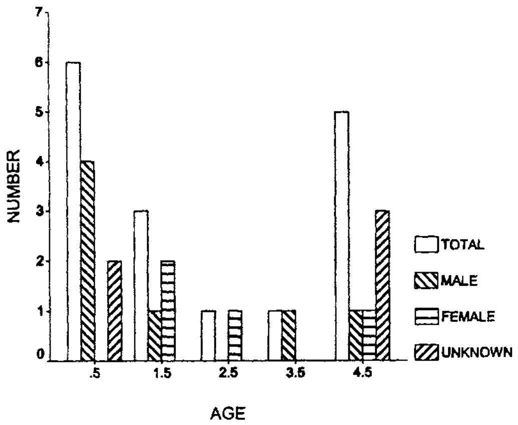

Fig. 6. Age distribution of tule elk remains recovered, 1995–1998, Point Reyes National Seashore, California, USA. Age class 4.5 represents ages 4.5 years and older.

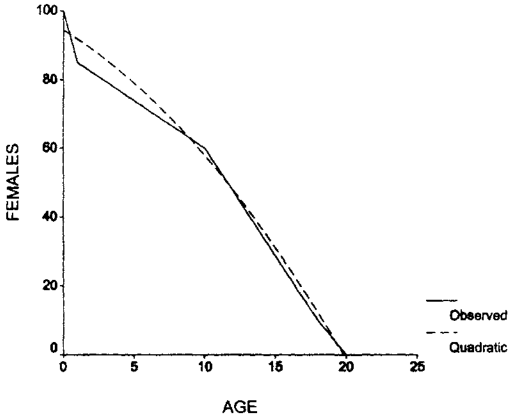

Fig. 7. Survival curve for original tule elk cows released between 1978 and 1980, Point Reyes National Seashore, California, USA.

Two animals were removed from the population during 1997 after they exhibited signs of diarrhea. One tested positive for Johne's disease while the other did not. Several additional cow elk showed signs of diarrhea. One radiomarked cow was removed during 1998 for this reason. These animals were repeatedly tested for Johne's disease, but the tests remained negative (Shideler et al., in press). From necropsy reports of 7 animals prepared by the California Department of Fish and Game and the Veterinary Health Sciences Laboratory, University of California at Davis, we determined that 15 factors contributed to poor health or death (Table 4). Although mountain lion (*Puma concolor*) and bobcat (*Felis rufus*) were observed on the elk range, the most numerous predators were coyote (*Canis latrans*), which we observed on a regular basis. We found no evidence of direct predation by felids, such as covered carcasses. We found 1 calf that had been gnawed by a canid but were unable to determine whether it was predation or scavenging.

Table 4. Diseases reported in 7 elk recovered and necropsied, Point Reyes National Seashore, California, USA, 1996–1998.

Disease	Number infected
Abomasitis	4
Blue tongue	2
Bronchitis	2
Encephalomalacia	2
Enteritis	2
Enterocolitis	2
Johne's disease	2
Pneumonia	2
Presumptive selenium deficiency	2
Umbilical infection	2
Colitis	1
Intestinal cestodiasis	1
Myocarditis	1
Pancreatic necrosis	1
Steatitis	1

Cow Survival.—During the course of the study, we continued to see an old cow that was ear-tagged during the original releases or was a calf born during spring 1981. In reviewing park records, we observed that 4 ear-tagged cows were observed approximately 10 or more years after release or tagging as calves (O. L. Wallis, National Park Service volunteer, 1990 field notes). The "old cow" was removed during 1998 because of diarrhea to be tested for Johne's disease and was shown to be negative for the disease. Based on these data, we estimated survival and longevity for adult females to be as high as 20 years (Fig. 7). Four cows (excluding the case of capture myopathy) of the 38 radiomarked cows died during the 3-year study, resulting in a mortality rate of 0.035 yr^{-1}. The annual mortality for 1996, 1997, and 1998 was 0.150, 0.000, and 0.058, respectively (mean = 0.069, n = 3, SE = 0.044). We plotted the 2 mortality rates derived above as linear constants resulting in an average longevity of approximately 17 years (Fig. 8).

Calf Survival.—During 1996, 1 of 12 radiomarked calves died by fall. Calf survival was 0.92. During November 1996, we counted 380 elk, of

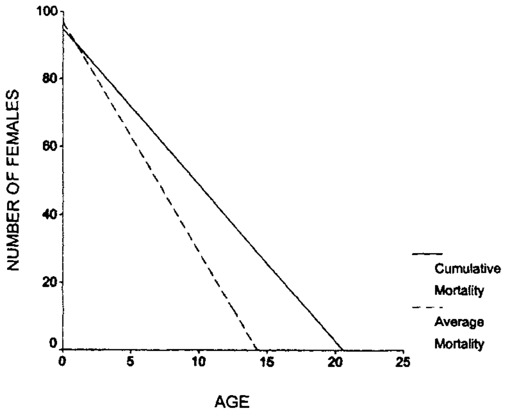

Fig. 8. Survival curves estimated for tule elk cows, 1995–1998, Point Reyes National Seashore, California, USA.

which 90 were calves. During spring and summer 1997, we captured 26 calves, of which 22 survived through the summer. Calf survival was 0.85. Also during 1997, we estimated that 121 calves were born and counted 103 calves by late summer. Calf survival was 0.84. A single instance of winter calf mortality was noted for 1997. Extrapolating from this observation, the winter calf survival was estimated at 0.96 during 1996. This resulted in an overall survival estimate of 0.81 for 1997. During 1998, we captured 28 calves, of which 24 (85.7%) survived to the fall herd count. Aged remains of tule elk showed a similar pattern of higher mortality among younger age classes (Fig. 6).

Density

Radiomarked cows observed at dawn, dusk, or night showed that the elk did not use different habitats from those occupied during the day. The observations indicated that elk remained in the same areas at dawn that they occupied overnight. We observed movement within habitat types away from roads and trails as park visitors arrived in late morning. Movement toward roads and trails often was seen late in the day, but usually did not take the animals into different habitats. We noted that the elk segregated into 2 subherds—north and south—over 4 biological seasons (Figs. 9A,B,C,D). The larger group was located in the south. Based on an analysis of relocations, some cows occasionally had 1 relocation in the other group then returned to their original group. Although we observed a continued increase in cow–calf herd size, we observed no change in herd range size of 354, 351, and 328 ha from 1996 to 1998 (90% isopleth; Table 5). Cow–calf densities were 0.733, 0.840, and 1.045 elk ha^{-1} during 1996, 1997, and 1998, respectively. Herd range sizes for the cow–calf subherds were different between the northern and southern groups—95 versus 249 ha. Bull herd range was 609 ha and densities were 0.279 elk ha^{-1} during 1997 (Table 6). The core use areas of bull herd locations were highly displaced from cow–calf subherd core areas (Fig. 10). Cow–calf herds were located in grassland and grassland–shrub habitats while bulls were located in heavy brush habitat. We applied the cow–bull density estimates to the entire range; we estimated maximum numbers of 741 cows–calves and 282 bulls for the 1,052-ha range. This translated to an estimated upper limit of KCC = 1,023 elk during wet years, such as El Niño periods, when precipitation was >1,024 mm year^{-1}.

Herd Growth Stabilization Modeling

We modeled the time necessary to reduce the net reproductive rate to 1 with 3 scenarios: removal, contraception, and removal and contraception combined. Contraception of 50 of the cows reduced λ, but it remained above 1 (1.097) after a model run. Lambda was reduced to 1.059 by removing 25 bulls and 25 cows yr^{-1}. By adding contraception to this rate of removal, λ was reduced to 1.052. Lambda was reduced to 1.0 with a combination of contraception and removal. With contraception of 50 cows, we calculated that 37 cows needed to be removed to reduce λ to 1.0.

DISCUSSION

Demographically, the Point Reyes herd was at the upper limit of estimated values for population parameters and growth at the end of 1998. Adult elk survival was approximately 95%, similar to values reported by Eberhardt et al. (1996) for Rocky Mountain elk (*C. e. nelsoni*) in eastern Washington. Calf survival was 85%, which was higher than 60% reported for Owens Valley tule elk (McCullough 1969) and similar to that of domestic sheep (Caughley 1976). Cow longevity was also greater—approximately 17 years versus 10 years for the Owens valley elk (McCullough 1966). Allen (1996) reported an annual growth rate of 0.213 for Rocky Mountain elk in Bandelier National Monument, New Mexico, similar to the Point Reyes mean of 0.223. McCullough (1969) estimated the maximum theoretical population growth rate for tule elk to be 0.25. The Point Reyes elk herd had a growth rate of 0.194 based on the exponential model, which is 0.054 higher

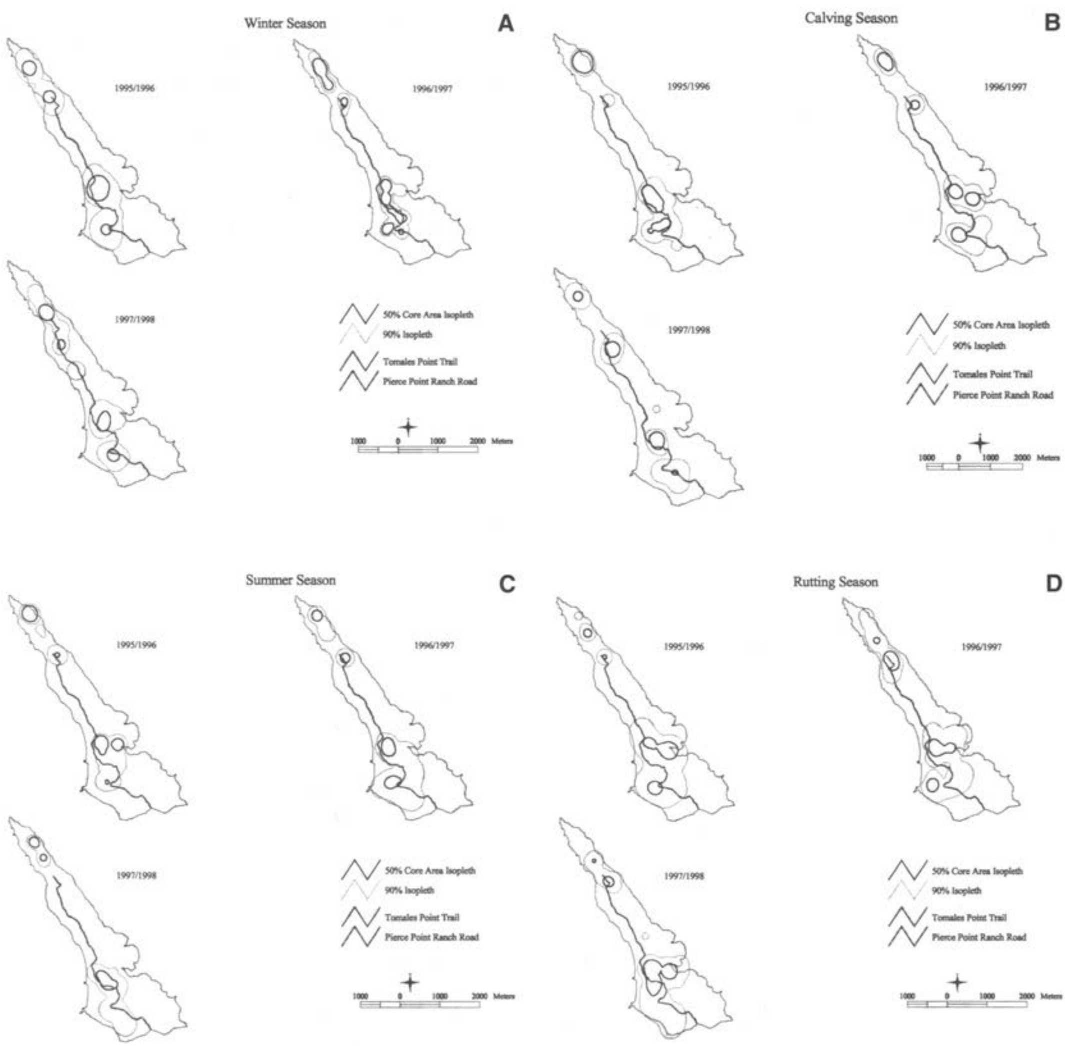

Fig. 9. Cow tule elk herd distribution during 4 biological seasons, Point Reyes National Seashore, California, USA, 1995–1998. (A) Winter, 1995–1996, 1996–1997, and 1997–1998. (B) Calving, 1995–1996. (C) Summer, 1995–1996, 1996–1997, and 1997–1998. (D) Rut, 1995–1996, 1996–1997, and 1997–1998.

than the Owens Valley elk herd (McCullough 1969) but similar to 0.20 reported by Eberhardt et al. (1996). By calculating the population doubling time ($2N_0 = N_0e^{rt}$) using the estimated exponential rate of increase (0.194), the Point Reyes herd was doubling every 3.6 years during the study period. Gogan and Barrett (1987) estimated herd growth rates to be $r = 0.17$ and $r = 0.29$ at Point Reyes. Both values were in the range of rates of increase observed in this study. They noted that the higher rate occurred from 1982 to 1984, the period coinciding with the first El Niño event.

Combining Gogan and Barrett's (1987) strong El Niño observations with our data shows a significant increase in growth rate of the population during these events. During the herd growth period between El Niño precipitation events 1982 to 1994, we found evidence of declining r with increasing N supporting the idea that density-related growth rates may be occurring during dry years. However, higher than normal precipitation during the El Niño years of 1995 through 1997 resulted in higher forage and calf production overriding density effects that appeared before 1995. During 1982, cattle were removed from the

Table 5. Seasonal cow tule elk herd range size (90% isopleth), northern and southern portions of the Tomales Point tule elk range, Point Reyes National Seashore, California, USA, 1995–1997.

Period	Season	Variable	Range size (ha) North	South	Total
Nov 1995–Oct 1996	Winter		169	267	436
	Calving		65	198	263
	Summer		82	172	254
	Rut		53	408	461
		Mean	92	261	353
		SE	26.3	52.9	55.1
Nov 1996–Oct 1997	Winter		85	144	229
	Calving		74	212	286
	Summer		91	318	409
	Rut		147	333	480
		Mean	99	251	351
		SE	16.3	44.9	57.8
Nov 1997–Oct 1998	Winter		125	220	345
	Calving		110	150	260
	Summer		43	204	247
	Rut		94	366	460
		Mean	93.3	235	328
		SE	17.8	46.2	49.1

range, releasing the vegetation from grazing pressure while the tule elk herd was still small, thereby confounding the precipitation results. McCullough (1992) described a theoretical density-dependent reproductive response for bighorn sheep as a flat curve until the curve sharply dropped at the high population density. Negative population response occurred quickly at a critical high density. Hassell's (1975) empirical study supported this pattern. The Tomales Point elk herd appeared to be in the flat or no-response phase during the study period. When the central California coast experiences several years of drought, we predict the final growth phase described by McCullough (1992); i.e., decreasing growth, zero growth, and a sharp decline.

Table 6. Bull elk herd range size (90% isopleth), northern and southern portions of the Tomales Point tule elk range, Point Reyes National Seashore, California, USA, 1997.

	Range size (ha) Total	Nonbreeding Rutting	(mid-Jul –mid-Oct)
All bulls	609	799	740
Prime bulls	660	655	909

During simultaneous counts using aerial, ground-drive, and horseback counts, we speculate that ground-drive counts underestimated the number of calves, and aerial counts underestimated the number of spike bulls. Both methods resulted in higher estimates of cows. Ground-drive count bias most likely was due to difficulty differentiating older calves from cows. Aerial count bias likely was due to the greater distance between observer and elk than that of ground-drive and horseback counts. We hypothesize that horseback counts provide better herd composition estimates because observers approach elk more closely and minimize the potential for double-counting.

Although coyote sightings were more common during 1997 than during previous years, no instance of predation on neonates was documented. We observed a calf carcass with evidence of coyote feeding, but the cause of death was indeterminate. Two calf carcasses that were later necropsied had bacterial infections; infections may be an important source of neonatal mortality.

During 1997, park management began an experimental contraception program to assess its feasibility for regulating the Point Reyes herd. Contraception temporarily blocks pregnancy, thereby eliminating the possibility of natural selection to operate on life history stages of individuals. Kucera (1991) and D. McCullough (University of California at Berkeley, personal communication) report that tule elk exhibited much less genetic variation than conspecifics because of a series of extremely low population numbers experienced since their near extinction. However, deleterious effects of reduced genetic variation on tule elk have yet to be demonstrated. Without the potential to increase genetic variation through mutation and recombination, the Point Reyes herd could eventually suffer from problems associated with inbreeding depression or genetic drift to extinction (Allendorf 1983, Chesser 1983).

The genetic consequences of contraception need to be explored for the Tomales Point herd. Natural selection operates on individuals in a population because of genetic differences among them. Unmanaged contraception could prevent individuals from entering the population, which would limit the palette of genetic diversity (Chesser 1983).

Park management and California Department of Fish and Game set a goal to limit the population to 600 elk on the range. It was estimated that this number, if held, should ameliorate the range impacts of the elk as forage production drops

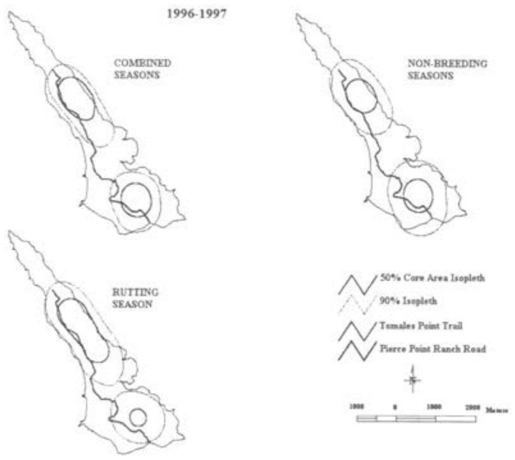

Fig. 10. Bull tule elk herd distribution, Point Reyes National Seashore, California, USA, 1996–1997.

during dry years (Bayless 1998). If KCC of the range drops below 600 due to poor range production, we would expect some density-dependent effects to appear, such as increased mortality from disease, reduced calving rates, lower cow:calf ratios, and greater bull mortality.

The exponential growth model of the Tomales Point herd indicated that the population growth phase during our study showed little evidence of density dependence or natural regulation. Quality and quantity of forage appeared to remain high, and the elk appeared to be in good condition.

Using a simple model, we examined the effort required to reduce the net reproductive rate (λ) from >1.0 to 1.0. From the model results, a combination of removal and contraception would have the most rapid reduction of net reproduction rate. We think the model reflects the order of magnitude of effort required to bring the population at Tomales Point to relative equilibrium.

At Tomales Point, changes in elk population growth rate were associated with precipitation and may be increased during strong El Niño years. During these periods of good plant production, we estimate the KCC of the range to be about 1,000 animals on the basis of our density estimates and extrapolation of declining growth rates with population size during inter-El Niño periods. California experiences prolonged periods of drought that will significantly lower KCC of the range. In a closed system like Tomales Point with no emigration, we would expect the herd to overshoot KCC and die back during prolonged drought.

In conclusion, our KCC estimates are based on density determinations for cows and bulls that tended to utilize different parts of the Tomales Point range. The 2 cow subherds had similar density increases, and we assumed their contribution to KCC would be proportional. Our estimate of 1,000 elk does not account for differences in forage quantity or quality. We would expect that during drought years, KCC would be much reduced, as much as 50% or more. Based on population growth rates and population size for dry years, KCC would be about 350 animals. This herd size may well be the target population level for which the park should manage. Although 3 species of predators occur on Tomales Point, predation caused little elk mortality during this study. Disease played a role in the mortalities we observed. Given the population growth characteristics, this population can rebound quickly. Removal rates should be optimized using current demographic information to effectively reduce the population rate of increase and remain cost-effective for management.

ACKNOWLEDGMENTS

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Effects of human-altered landscapes on a reintroduced ungulate: Patterns of habitat selection at the rangeland-wildland interface

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ABSTRACT

Successful species reintroductions require land managers to balance the goal of viable wildlife populations with potential risks to human enterprise. Such risks are particularly acute at the wildland-agriculture interface, where native and domestic species are likely to come into contact. In a national park in northern California, we combined insights from three lines of evidence – long-term visual surveys, short-term GPS telemetry, and satellite remote sensing-based animal detections – to characterize spatial overlap between reintroduced tule elk (*Cervus canadensis nannodes*) and domestic cattle and to estimate the importance of multiple environmental features as predictors of habitat selection by elk. Our results indicate that, at large spatial scales (i.e., home-range level), cattle were the primary driver of habitat selection, with the occurrence of elk being negatively associated with cattle across all seasons. In addition, elk consistently selected for grasslands on gentle, south-facing slopes that occurred at high elevation and close to ponds. NDVI was a seasonally important, positive predictor of habitat selection, with a marked reversal when this resource was concentrated inside of fenced cow pastures during the dry summer months. By contrast, a novel analysis of satellite-derived animal locations yielded no evidence of avoidance of cattle by elk (within pasture areas commonly used by elk), indicating that this population has acclimated to the presence of cattle through spatial partitioning of resources. Thus, this once-imperiled native ungulate exhibits patterns of habitat selection that reduce the potential for grazing conflicts with cattle, even in cases where access to forage is limited.

1. Introduction

Following centuries of megafaunal declines in North America, numerous restoration projects have aimed to return native populations of wildlife to their known historical ranges (Seddon et al., 2014). These efforts have produced notable conservation achievements, but also revealed a number of significant challenges associated with maintaining free-roaming wildlife populations in proximity to human-modified landscapes (Armstrong and Seddon, 2008). The growing literature on this topic suggests that such challenges are often amplified in agricultural landscapes, where reintroduced megafauna may come into contact with closely related domestic species (Hibert et al., 2010; Merkle et al., 2018; Proffitt et al., 2011). Given the documented potential for conflict (e.g., forage competition, behavioral exclusion, disease transmission) between livestock and reintroduced ungulates, much of this literature has focused on documenting the effects of interactions between these two groups.

Importantly, this research suggests that interactions between livestock and native ungulates are complex and can range from competition to facilitation, depending on the natural history of the system (Scasta et al., 2016; Schieltz and Rubenstein, 2016). For example, the ability to migrate is one of many factors that may reduce pressure on shared resources (at least seasonally) and contribute to an increased likelihood of sustained coexistence between wildlife and livestock. However, a reintroduced population that does not migrate, and thus remains in contact with livestock year-round, raises a suite of unanswered questions about

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the ecological mechanisms that explain the coexistence of these two potentially competing populations. Likewise, the question of scale looms large when seeking explanations for observed ecological patterns, as processes observed at one scale may not persist when assessed from an alternative scale (Chave, 2013). As a result, clarifying both the mechanism and scale of an ecological pattern is critical to obtaining actionable conservation insights and accurately assessing the potential for conflict between reintroduced megafauna and domestic livestock.

The challenge with this approach, however, is that it requires detailed information on the simultaneous distributions of wildlife and livestock over large expanses of space and time- data which is notoriously difficult to acquire. Our study aims to address such limitations by presenting a novel application of emerging satellite remote sensing (SRS) technology to quantify species interactions and patterns of habitat selection at a rangeland-wildland interface in northern California. This unique study site afforded several strategic advantages for SRS-based research, including a moderately sized (n = 93), non-migratory population of reintroduced tule elk (*Cervus canadensis nannodes*), open landscapes with high visibility, and long-term datasets on the distribution of elk and cattle across the entire study area. When combined with SRS-derived animal locations, these datasets (e.g., GPS telemetry and visual surveys) yielded scale-dependent insights into the habitat selection processes that contribute to the persistence of a reintroduced ungulate in a cattle-dominated ecosystem.

Specifically, we used SRS-derived animal locations to produce a spatially explicit time series of livestock densities across the entire study area. We then used GPS telemetry and visual surveys to identify large-scale, seasonal patterns of resource selection by elk in response to this gradient of livestock densities. Finally, we applied the SRS-derived animal locations to a fine-scale investigation of the drivers of coexistence between elk and livestock across the system. By combining insights from multiple data streams, we revealed that coexistence between elk and cattle is maintained by a unique combination of avoidance (at large scales) and tolerance for proximity (at small scales). As such, this study yields new insights into the nature of interspecific interactions in this ecosystem, while providing a novel and replicable model for quantifying the dynamics of livestock-wildlife interactions in remote landscapes elsewhere.

2. Materials and methods

2.1. Study area

Our research was conducted in Point Reyes National Seashore, approximately 65 km northwest of San Francisco, California. The region experiences a Mediterranean climate, with moderate, rainy winters (mean temperature 10 °C, mean rainfall 17 cm) and cool, foggy summers with very little precipitation (mean temperature 14 °C, mean rainfall 14 cm; [dataset] "Western Regional Climate Center", 2020). The study site (hereafter, 'Drake's Beach') encompasses a 30 km^2 area comprised of fenced dairy cattle ranches (ca. 18 km^2, operated under lease agreements with the National Park Service) and adjacent wildlands that are not grazed by cattle (ca. 6.5 km^2; Fig. 1). Ranches are dominated by open coastal scrub (*Baccharis* spp. *and Lupinus arboreus*; 47% cover), barren sand dunes (16% cover), and highly disturbed active pastures (14% cover). Native grassland composes <7% of this habitat type. Wildlands are dominated by native grassland (53% cover), dune vegetation (*Lupinus chamissonis*, *Artemisia pycnocephala*, *Ammophila arenaria*; 21% cover), and open coastal scrub (*Baccharis* spp. *and Lupinus arboreus*; 7% cover). The relatively flat (elevation ranges from sea level to 112 m), open landscape is bisected by two paved roads that afford unobstructed views across 95% of the study area.

Fig. 1. Map of study area within Point Reyes National Seashore, CA. Elk home range represents a 95% autocorrelated kernel density estimate (Fleming and Calabrese, 2016) for all collared elk in the study area (n = 8, data collected from 2012 to 2017). Survey sites are shaded to indicate relative mean density of elk, darker shades indicate higher density.

2.2. *Study species*

Originally extirpated from the Point Reyes peninsula due to hunting and habitat loss, tule elk were absent from the study area for at least 100 years before a small group ($n = 28$) was reintroduced to a designated wilderness area in 1999 (Howell et al., 2002). Soon after reintroduction, several elk dispersed to the current study area and established a new population that numbered 93 animals as of 2016 (Bernot and Press, 2018). This group is known as the 'Drake's Beach Herd' and inhabits a home range of ca. 6 km^2 within the Pastoral Zone of Point Reyes National Seashore (Fig. 1). Hunting is prohibited throughout the study area and previous research suggests that predation is not a significant source of mortality for elk in this ecosystem (Cobb, 2010; Thomas and Toweill, 2002).

2.3. *Elk activity and habitat characteristics*

We used three complementary datasets to assess elk activity and selection of habitats at the following scales: (1) Home range scale (visual surveys and GPS telemetry) and (2) Pasture scale (satellite remote sensing-based animal detections). The use of multiple datasets allowed us to make robust conclusions about patterns observed at the home range scale and derive new insights about the mechanisms that maintain coexistence between elk and cattle in this system. For all analyses, we partitioned elk activity into four biologically relevant seasons: wet season (November–April), parturition (May–June), summer (July–August), and mating season (September–October).

2.3.1. *Visual surveys*

All surveys ($n = 589$) were performed between September 2010 and October 2017 (mean = 73 surveys/year) by the same park biologist, who conducted weekly elk counts from a vehicle during crepuscular hours (generally 06: 00–10:00 and 17:00–19:00, 15% of surveys occurred outside of these times). Surveys were driven in a consistent direction (north to south) and constant speed (10 mph) along the same portion of paved roadway that afforded unobstructed views across 76 established survey points and >95% of the study area (Fig. 1). At each site, the observer recorded all elk within a ca. 50 m radius of the survey point. Given the relatively small size of the study population ($n = 93$) and frequency of surveys (weekly, year-round), the observer was able to determine the exact number of groups to expect on each survey and would end the survey once all groups had been located. Likewise, the small home range (6 km^2) with excellent visibility allowed the observer to monitor the locations of all previously counted groups so that none were double counted. Finally, to minimize detection bias introduced by poor visibility, we removed all surveys on days with heavy fog (< 4% of the data).

2.3.2. *GPS telemetry*

Between 2012 and 2018, 8 adult elk (3 males and 5 females, 10% of adult population) were chemically immobilized via dart gun and collared with a GPS transmitter (all animals were captured according to protocols approved by the National Park Service Institutional Animal Care and Use Committee and following established guidelines; Appendix A). Collars collected one location every three hours and were deployed for 3 to 31 months (mean = 17 ± 8 [SD] months; Appendix A).

2.3.3. *Satellite remote sensing-based animal detections*

We manually georeferenced the locations of individual elk and cattle (using 'BisQue'; (Kvilekval et al., 2010) identified within fenced cow pastures (Fig. 1) using archived, high-resolution satellite images (i.e., ≤ 50 cm panchromatic images from WorldView-2/3 and GeoEye-2 satellites; $n = 31$). Each image provided coverage of the entire study area and was collected from 2012 to 2017 at 10:00 or 14:00 local time. A trained observer followed a standardized protocol to classify each species (Fig. 2) and the same expert observer manually validated all entries. Note that pens that temporarily held cattle adjacent to ranch compounds were excluded from analysis. It was not possible to evaluate detectability from this archived dataset, but we minimized detection bias by limiting the analysis to grazed pastures (i.e., wildlands were excluded), which did not have vegetation present at a height or density that might obscure animals from above. In addition, there were no other large mammal species (e.g., black-tailed deer) detectable at this resolution. This resulted in the following distribution of seasonal population surveys across the study area: wet season ($n = 19$), parturition ($n = 3$), summer ($n = 1$), and mating season ($n = 8$).

2.3.4. *Habitat characteristics*

We obtained data on the spatial extent of habitat characteristics known to be important to the selection of habitat by elk (Cobb, 2010; Stewart et al., 2015). These features included: fenced cattle pastures, cattle density within fenced pastures, vegetation cover (e.g., percent cover for scrub, dry grassland, moist grassland, and heavily grazed grassland), distance to ponds, slope, aspect, and elevation ([dataset] Kinyon, 2015; Table 1). We then computed slope 'northness' (i.e., a proxy for solar radiation) as the cosine of aspect and used the mean Normalized Difference Vegetation Index (NDVI) for each season as an index of seasonal forage availability (computed using Landsat Tier 1 data accessed and processed via Google Earth Engine; Gorelick et al., 2017). We then masked land cover types that might confound NDVI

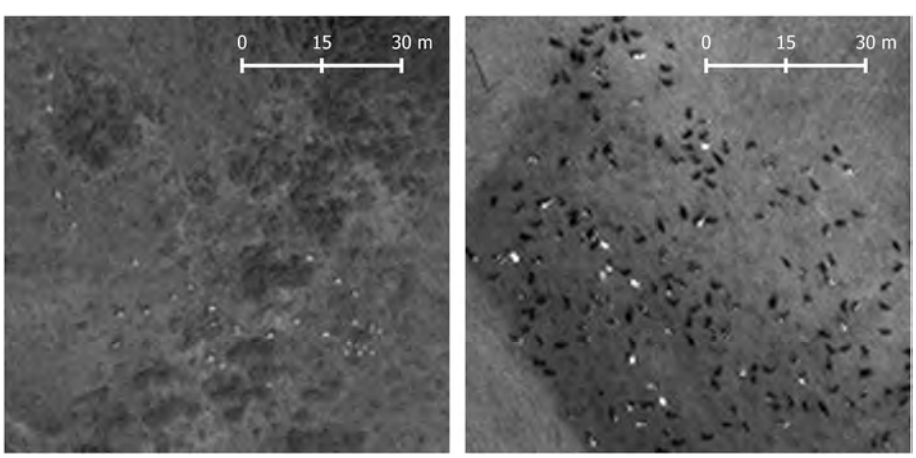


Fig. 2. Representative satellite images of elk (left) and cattle (right). Note that elk (smaller, lighter colored, generally lower density) and cows (larger, darker or multi-colored, generally higher density) differ with respect to size and color of individuals, as well as herd size. Examples shown are unprocessed panchromatic images, collected at 50 cm resolution (WorldView-2 satellite imagery © Maxar Technologies).

Table 1
Fixed effects included in the global model. The global model used visual survey and GPS collar datasets to quantify habitat selection for tule elk in the Drake's Beach herd at Point Reyes National Seashore 2010–2018. Random effects included: Elk ID, Site ID, and Year.

Category	Covariate	Definition	Unit	Cell size (m^2)	Mean	SD
Environment	Elevation	Height above sea level	Meters	100	51.4	23.2
	Northness	Relative measure of direction of slope face (i.e., cosine (aspect))	−1 to 1	100	0.0	0.6
	Ponds	Distance to nearest pond	Meters	100	407.5	271.3
	Slope	Slope of terrain	Degrees	100	18.0	12.7
Livestock	Cattle Density	Mean (non-zero)[a] density of cattle within cell during season of interest	Cows/acre	100	–	–
	Pasture	Land within the boundaries of a ranch lease	% cover	100	80.1	37.8
Vegetation	Grassland: Dry	Vegetation type (e.g., *Baccharis* spp., *Lupinus* spp.)	% cover	100	55.2	43.4
	Grassland: Heavily Grazed	Highly disturbed vegetation due to agricultural activities (exclusive of silage or crop production)	% cover	100	17.1	35.6
	Grassland: Moist	Vegetation type (e.g., *Deschampsia* spp., *Carex* spp., *Juncus* spp.)	% cover	100	11.7	26.6
	NDVI	Median NDVI (Normalized Diference Vegetation Index) for season of interest	-1 to 1	900	–	–
	Scrub	Vegetation type (e.g., *Baccharis* spp., *Rhamnus* spp., *Toxicodendron* spp.)	% cover	100	22.0	35.7
Interactions	NDVI * Cattle Density	–	–	–	–	–
	NDVI * Moist Grassland	–	–	–	–	–
	NDVI * Scrub	–	–	–	–	–
	Slope * Cos Aspect	–	–	–	–	–

[a] Median density used for wet season models in all datasets.

calculations (i.e., water, beaches, dunes, and riparian vegetation) and rasterized all vector datasets to 10 m resolution ("raster" package; Hijmans, 2017). Seasonal cattle densities were estimated for fenced pastures (Fig. 1) by summarizing the SRS-based detections (see Section 2.3.3) as follows: (1) mean density per pasture; (2) median density per pasture; (3) mean density of non-zero counts per pasture; (4) median density of non-zero counts per pasture. Model selection was then used to determine the most appropriate 'cattle density' metric for each season (see Section 2.4.1).

2.4. Data analysis

2.4.1. Visual surveys

To address concerns about the independence of surveys conducted on the same day, we randomly rarefied the data to no more than one survey per day (thereby eliminating 18% of surveys). We then used the number of elk observed at each survey site per visit as our primary response variable. Mean covariate values (Table 1) within a 50-m radius buffer of each survey point served as covariates. We rescaled all quantitative covariates prior to analysis (by subtracting the mean from each input variable and dividing by two times its standard deviation; Gelman, 2008) and removed any with pairwise $r > 0.5$ or VIF > 3 (Zuur et al., 2009). As a result, streams were the only covariate removed from the analysis prior to model selection.

We modeled elk counts using a zero-altered (hurdle) negative binomial (ZANB) process model with a logit-link for the zero-prediction component and a log-link for the count-regression component ("glmmTMB" package; Magnusson et al., 2016; Zuur et al., 2009). The full ZANB model included the full set of environmental covariates and interactions in both the zero-prediction and count components. We modeled 'Year' and 'Site ID' as random-intercepts for both the zero-prediction and the count-regression components to account for potential sources of non-independence such as spatial clustering. We assessed goodness-of-fit for the full model by visually examining scaled (quantile) residuals and performing diagnostic tests (uniformity, overdispersion, zero-inflation, outliers) using the "DHARMa" package (Hartig, 2019).

For each season, we employed a two-step information-theoretic approach to model selection of habitats, in each instance selecting the lowest-AIC model (Burnham and Anderson, 2007): (1) We selected the best-performing estimate of cattle density from among the four candidate estimates (mean, median, mean non-zero, median non-zero; see Section 2.3.3), and (2) We then used backward stepwise selection ("buildmer" package; Voeten, 2019) based on AIC to remove any variables and interaction terms that were uninformative for both the zero-prediction and count-regression sub models. It should be noted that although these models necessarily treated observations as independent, the Drake's Beach Herd regularly moves as a single group, so confidence intervals on coefficients (and corresponding "significance") should be interpreted with caution.

2.4.2. GPS telemetry

We fitted seasonal Resource Selection Function (RSF) models using a generalized linear mixed modeling framework (GLMM) with a binomial error distribution and a logit-link. Available (background) points were randomly selected from within the 100% minimum convex polygon enclosing all known elk locations ($n = 5\times$ the total 'used' locations from telemetry). Covariate values (Table 1) were computed as the mean value within a 25 m radius of each 'used' or 'available' point (approximate scale of GPS error). We rescaled covariates and tested for collinearity as described for the visual survey analyses. Among-individual variation in habitat selection was modeled with random effects for all model coefficients (Gillies et al., 2006). Models were fitted using the "glmmTMB" package (Magnusson et al., 2016). Following Muff et al. (2019), we fixed the variance for the random intercept term at a high value and "infinitely" weighted used and available points. Finally, we used backward stepwise selection ("buildmer" package; Voeten, 2019) based on AIC to remove any uninformative variables and interaction terms. It should be noted that although these models necessarily treated individuals as independent, the Drake's Beach Herd regularly moves as a single group, so confidence intervals on coefficients (and corresponding "significance") should be interpreted with caution.

2.4.3. Satellite remote sensing-based animal detections

We first examined differences in the spatial distributions of georeferenced elk and cattle using a multi-response permutation procedure (MRPP; Talbert and Cade, 2013). This involved testing whether mean within-group Euclidean distances (i.e., cattle to cattle or elk to elk, aggregated across all 28 satellite images where elk were observed in cow pastures) were shorter than mean elk-cattle distances (Stewart et al., 2015). We report the average within-group pairwise distance (or delta value), which is a descriptive metric of spatial dispersion, and a p-value from the permutation procedure (fraction of permutation-based delta

values that are lower than the observed delta value; Oehlers et al., 2011; Stewart et al., 2015; Talbert and Cade, 2013). Since MRPP is not sensitive to spatial scale, delta values are a descriptive measure of spatial dispersion and we used them to establish a null model of group cohesion (Oehlers et al., 2011), as a preliminary step in the subsequent analysis.

To test whether observed differences in space-use by elk vs. cattle resulted from behavioral avoidance, we developed a bootstrap procedure to generate a distribution of elk locations under a null model (no cattle avoidance). To do this, we first aggregated all elk locations across all images where elk were visible inside of fenced pastures ($n = 28$) and constructed a kernel-density surface across our study site representing the probability of utilization by elk ("kde2d" function in the "MASS" package; Ripley et al., 2017). We then categorized elk into groups within each image (elk within 50 m of each other were considered part of the same group). Next, we used this kernel-density surface to generate hypothetical centroids for elk groups within each image (the number of simulated elk groups was held equal to the number observed in each image). For each image, we generated elk locations under the null model by sampling randomly from the observed distribution of location to group-centroid distances, holding the number of elk per group to observed values (directions from the group-centroid were generated randomly). For each bootstrap simulation replicate, we computed: (1) Mean distance from each simulated elk location to the nearest observed cattle location, averaged across all images ($n = 28$); (2) Minimum per-image distance from each simulated elk location to the nearest cattle location, averaged across all images; and (3) Proportion of elk groups occurring within 50 m of one or more cattle groups, averaged across all images. We compared the observed test statistics (e.g., mean distance from elk to nearest cattle location) with the distribution of each statistic generated under the null (no avoidance) model, and used this information to compute a *p*-value.

3. Results

3.1. Visual surveys

Visual surveys resulted in 1,792 observations of elk groups over 589 surveys (mean group size = 34, min = 10, max = 104; excluding zeros). The resource selection analysis conducted on the visual survey data indicated that, at the home range scale, all grazed cattle pastures were consistently avoided by elk (Figs. 3–5, Appendix B). Similarly, high cattle density had a consistently negative effect on selection by elk, regardless of season or NDVI value associated with cattle pastures (Figs. 3, 5, Appendix B).

Of the other environmental variables tested in our resource selection models, 'northness' (i.e., cos aspect) and elevation were consistently important for predicting selection of habitats by elk across all seasons except mating. Specifically, elk were more likely to be present in large numbers at high elevation sites and on south-facing slopes (Fig. 3, Appendix B). In addition, habitat near ponds was one of the most important

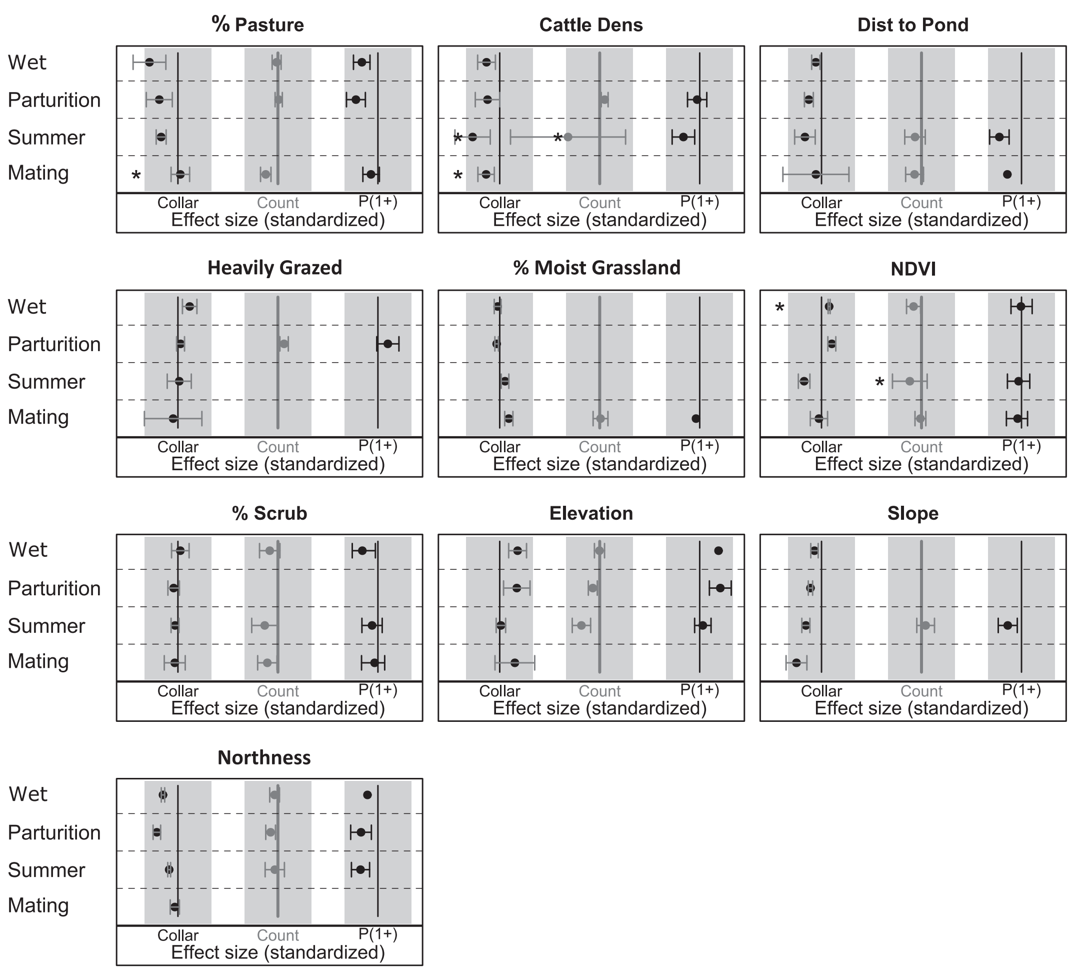


Fig. 3. Habitat selection coefficient estimates for tule elk at Point Reyes National Seashore. Coefficients were derived from GPS collar data (columns labeled 'Collar') and visual surveys (columns labeled 'Count' and 'P(1+)'), where 'P(1+)' represents probability of presence (one or more elk observed) and 'Count' represents expected elk abundance at occupied sites. Vertical lines indicate no effect, and gray regions represent standardized coefficient values between −2 and 2. Error bars represent 1 standard error (s.e). Asterisks denote that the estimated effect size and standard error was 5× larger in magnitude than what is depicted here (for visual clarity; see Appendix B for coefficient values).

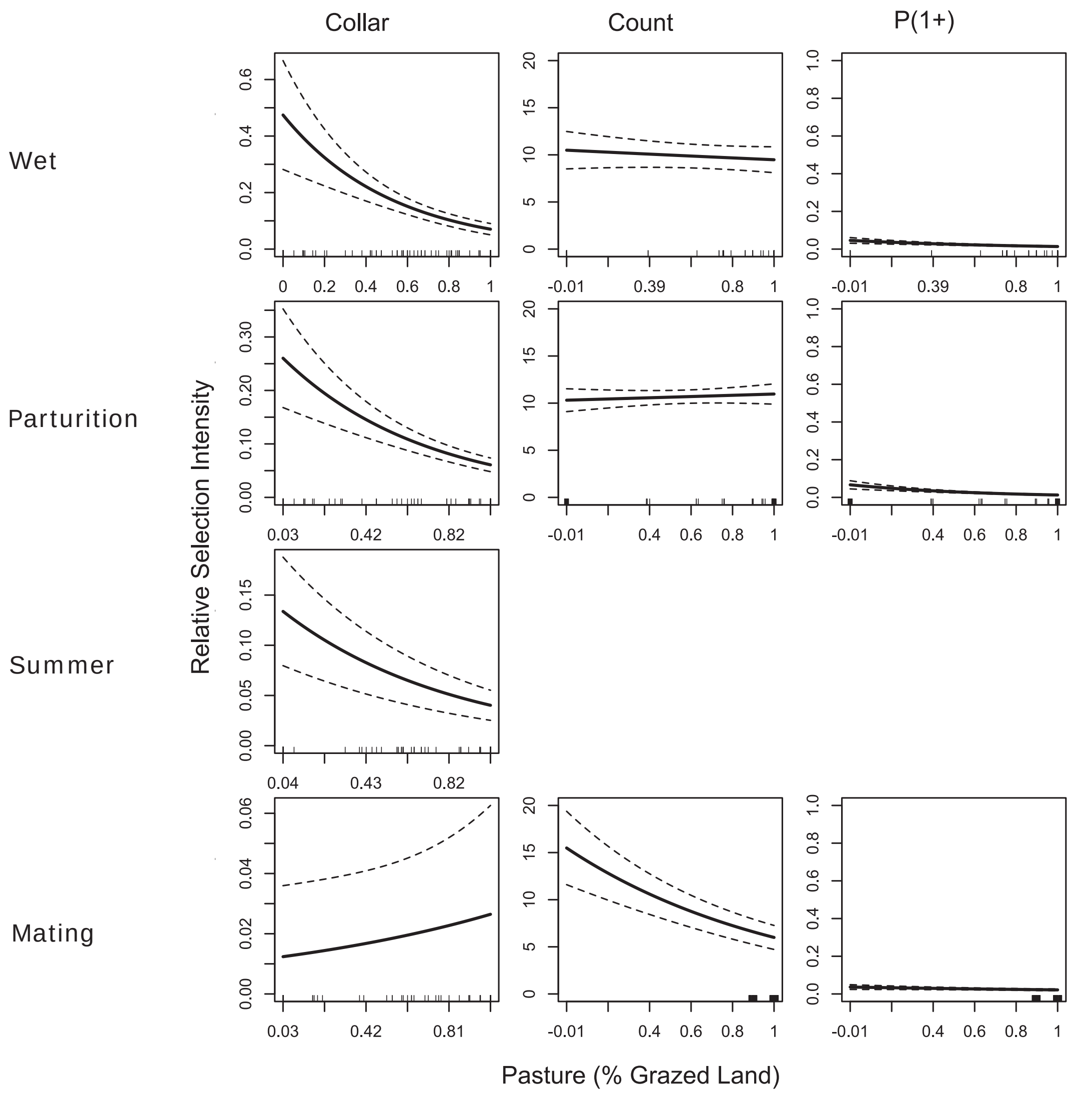


Fig. 4. Partial-dependence plots of elk habitat selection. Probability of habitat selection by elk as a function of the percentage of grazed land (Pasture) across multiple seasons and model types. Predictions were derived from GPS collar data ('Collar'; predictions represent point intensity) and visual survey data ('Count' and 'P(1+)'), where 'P(1+)' represents probability of presence (one or more elk observed) and 'Count' represents expected elk abundance at occupied sites. Blank panels denote that Pasture was not included in the top model for a particular season/model combination. Error bars represent 1 standard error (s.e).

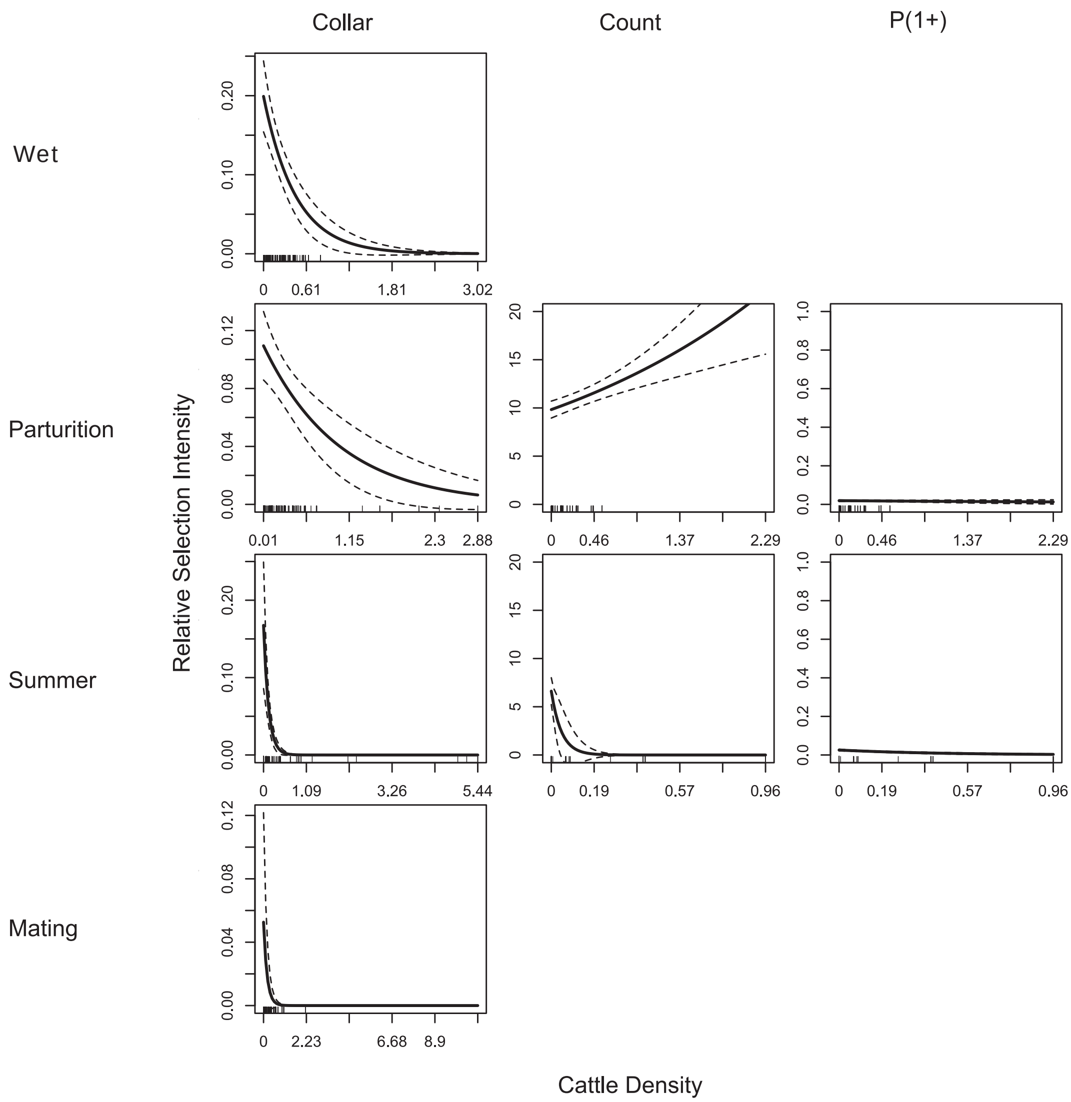


Fig. 5. Partial-dependence plots of elk habitat selection. Probability of habitat selection by elk as a function of cattle density across multiple seasons and model types. Predictions were derived from GPS collar data ('Collar'; predictions represent point intensity) and visual survey data ('Count' and 'P(1+)'), where 'P(1+)' represents probability of presence (one or more elk observed) and 'Count' represents expected elk abundance at occupied sites. Blank panels denote that Cattle Density was not included in the top model for a particular season/model combination. Error bars represent 1 standard error (s.e).

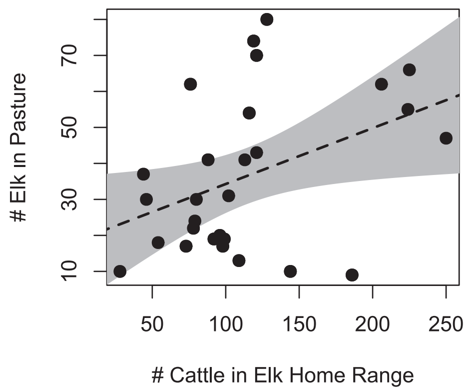


Fig. 6. Distribution of elk and cattle observed simultaneously in satellite images. Relationship between the number of elk observed in pastures at specific points in time (classified from satellite imagery; $n = 28$) and the corresponding total number of cattle observed within pasture areas commonly visited by elk (cattle occurring within the 95% kernel density contour for elk across all satellite images; $R^2 = 0.17$, adjusted $R^2 = 0.14$).

predictors of elk abundance for summer and mating seasons, while a gentle slope was an important predictor of elk abundance for summer only (Fig. 3, Appendix B). Grassland type (e.g., moist, dry, heavily grazed) was generally not an important predictor of elk abundance or presence for any season, although it was retained in the top models for parturition (heavily grazed only) and mating (moist grassland only). Both NDVI and scrub were retained in the top model for all seasons except parturition (Fig. 3, Appendix B).

For interactive effects, we found that, at high cattle densities, elk tended to avoid areas with high NDVI, whereas at low cattle densities elk tended to exhibit positive to neutral selection for NDVI (summer only; Appendix B). In addition, the relationship between elk presence and abundance with NDVI was always positive, but was generally weaker in areas of high scrub cover than low scrub cover (wet season only; Appendix B), as well as areas of high moist grass cover versus low moist grass cover (mating season only; Appendix B). Finally, at sites with gentle slopes, elk exhibited negative to neutral selection for north facing aspect (summer only; Appendix B).

3.2. *GPS telemetry*

GPS telemetry monitoring resulted in 29,014 fixes for 8 individuals (mean = 3,627, min = 594, max = 6,921 fixes/animal; mean fix success rate = 96%, min = 86%, max = 100%). The resource selection analysis conducted on this dataset indicated that, at the scale of the home range, all grazed cattle pastures were consistently avoided by elk (Figs. 3–5). Similarly, high cattle density had a consistently negative effect on selection by elk, regardless of season or NDVI value associated with cattle pastures (Figs. 3, 5, Appendix B). Of the remaining variables tested, 'northness' (i.e., cos aspect), elevation, and proximity to ponds were consistently important for predicting selection of habitats by elk across all seasons. Specifically, high elevation sites, south-facing slopes, and habitat near ponds were selected by elk (Fig. 3, Appendix B). Elk also generally selected for gentler slopes (Fig. 3, Appendix B). Although heavily grazed and moist grasslands were retained in top models across all seasons for this dataset, results showed strong selection for heavily grazed areas during the wet season only and moist grasslands during summer and mating seasons (Fig. 3, Appendix B). Dry grasslands were not retained in the top model for any season.

Selection along the NDVI gradient was seasonally variable, with selection for high NDVI sites during wet season and parturition, but avoidance of high NDVI sites during the summer (Fig. 3, Appendix B). As noted in Section 3.1, this pattern of avoidance was not corroborated by visual survey data, but a Wilcoxon Rank Sum analysis indicated that NDVI values were significantly lower outside of grazed pastures than inside and that this difference was most pronounced during the summer ($p < 0.001$, 95% CI [−0.125–0.115]; wet season: $p < 0.001$, 95% CI [−0.064–0.058]; parturition: $p < 0.001$, 95% CI [−0.029–0.022]; mating: $p < 0.001$, 95% CI [−0.021–0.009]). Elk also selected for high NDVI sites, regardless of moist grassland cover (Appendix B), but exhibited negative selection for NDVI at high scrub densities and positive selection for NDVI at lower scrub densities (except for the wet season when selection for NDVI was always positive; Appendix B). Finally, elk generally but weakly avoided scrub habitats across all seasons (Fig. 3, Appendix B) and selected for low slope areas, regardless of aspect or season (Appendix B).

3.3. *Satellite remote sensing-based animal detections*

The satellite image analysis resulted in 1,608 elk locations (mean = 51, min = 0, max = 98 elk, $n = 28$ images) and 26,943 cattle locations (mean = 869, min = 312, max = 1,251 cows, $n = 31$ images). Results from the multi-response permutation procedure indicated that the spatial distributions of elk and cattle within pasture areas were highly distinct and that cattle were more widely dispersed than elk (δ_{cattle} = 2,711, δ_{elk} = 1,203; $P < 0.0001$; Appendix C). Despite strong evidence for spatial segregation between elk and cattle, we did not observe behavioral avoidance of cattle by elk on the basis of satellite images; the observed distances between elk and cattle locations in any given image (total distance from each elk to nearest cow: mean = 516 m, min = 114 m, max = 1,433 m; minimum distance from each elk to nearest cow: mean = 361 m, min = 23 m, max = 1,378 m) did not significantly differ from a null model in which cattle locations had no effect on elk locations ($p = 0.28$ for mean distances and $p = 0.18$ for minimum distances; Appendix C). Individual cattle and elk, however, were never observed to come into direct contact and only 4% of observed elk groups overlapped with one or more cattle groups (overlap was defined as any individual elk occurring within 50 m of an individual cow), which was also consistent with a null model of no avoidance ($p = 0.31$; Appendix C). Furthermore, we detected a weakly positive relationship between elk use of pastures and the number of cattle occupying pasture areas commonly used by elk ($p = 0.03$, adjusted $R^2 = 0.13$, $n = 28$; Fig. 6), whereas a negative relationship might be expected under a cattle-avoidance hypothesis.

4. Discussion

Our study sought to explain patterns of habitat selection exhibited by a reintroduced population of elk that resides year-round in a rangeland shared with domestic cattle. By employing multiple, complementary data streams, we have identified patterns of habitat selection that vary across spatial scales but remain consistent over time. This approach revealed a more nuanced understanding of scale-dependent processes than would be possible from any single method and allowed the weaknesses of each dataset to be offset by the strengths of another. For example, location data from GPS collars and visual surveys revealed consistent patterns of habitat selection at the home range scale, while herd locations obtained from satellite images provided novel explanations for the patterns observed at both fine (< 100 m) and large (i.e., home range) spatial scales. Likewise, the low temporal resolution and large sample size of visual survey data was complemented by the high temporal resolution and limited sample size of the GPS collar data. These findings demonstrate the value of leveraging multiple methods for the study of habitat selection and highlight opportunities for the use of emerging satellite technologies to advance both basic and applied understanding of the rangeland-wildland interface.

Our analyses revealed that, at large scales, cattle-associated variables were the primary drivers of habitat selection by elk in this system, with elk occurrence being negatively associated with cattle density and cow pastures across all seasons. While it was not possible to fully disentangle

the effects of cattle presence from the effects of plant communities associated with cow pastures and wildlands (i.e., wildlands were dominated by native grassland while cow pastures were dominated by open coastal scrub), all vegetation variables we tested had a consistently smaller effect size than cattle density or proximity to pastures. Findings related to non-cattle variables were generally consistent with expectations for all species of North American elk (Thomas and Toweill, 2002), as well as previous studies of habitat selection by tule elk (Cobb, 2010; Huber et al., 2011). However, the degree to which cattle affected habitat selection by elk in this ecosystem was previously unknown and revealed unexpected relationships between cattle presence, vital resources, and habitat selection patterns of this once-imperiled native ungulate.

In temperate grasslands, NDVI typically serves as a reliable and positive predictor of habitat use by resident herbivores (Heffelfinger et al., 2020). While this relationship was evident for most seasons in our study, it was notably reversed during the summer, when NDVI values were significantly higher inside of cow pastures than in adjacent wildlands. As a result, we suspect that adult females with dependent young may have avoided cow pastures at the cost of grazing opportunities during this sensitive time of year. When combined with the patterns of avoidance documented at the home range scale, these observations strongly suggest that coexistence between cattle and elk is at least partially maintained by the tendency for elk to avoid cattle or cattle-associated habitats at large spatial scales. Although the limited sample size of this study prevented further exploration of sex-specific differences in resource selection, we present this finding to highlight the importance of considering this variable in future studies.

Despite the patterns of avoidance observed at large scales, we found little evidence for avoidance of cattle by elk at the pasture scale, which suggests that these species may exhibit an unusual tolerance for proximity at fine spatial scales (Stewart et al., 2002). While it is possible that this pattern was driven by a few bold individuals (i.e., $<$ 4% of SRS-derived elk observations were within 50 m of cattle) or the uneven temporal sampling of the satellite data (i.e., 87% of images are from wet and mating seasons, which account for 66% of the observation period), similar cases of behavioral habituation between elk and cattle have been reported from other ecosystems where both species occur year-round on shared pastures (Yeo et al., 1993). In addition, we found a weak, but positive correlation between aggregate abundance of each species across the study area (Fig. 6). Taken together, these results imply that avoidance of cattle at the home range scale is not driven by behavioral intolerance, but by the need to partition shared resources at fine scales. Indeed, results from all three methods (e.g., GPS collars, visual surveys, satellite-based location data) supported this conclusion by confirming that elk consistently selected habitat in a manner that reduced the potential for forage competition with cattle, despite the occurrence of cattle across the majority (ca. 75%; Fig. 1 & Appendix C) of available grazing habitat.

While these conclusions have been drawn from an isolated population of elk in a limited geographic area, the behavioral mechanisms that support coexistence in this ecosystem (i.e., tolerance for proximity at small scales, but not at large scales) may have important implications for restoration projects elsewhere. For example, a cattle-dominated landscape with sufficient adjacent native habitat might warrant deeper consideration as a megafaunal reintroduction site than previously thought. However, we note that this tolerance for proximity could quickly become a liability for ecosystem managers if populations of wildlife or livestock increase or resources become limited due to extreme climatological shifts (i.e., drought or frost). As a result, the relationship between population size, climate, and reintroductions of non-migratory species at the rangeland-wildland interface will remain an important area of research moving forward.

In addition to informing the basic ecology of megafaunal reintroductions in non-migratory systems, this study provides a broadly applicable framework for advancing the study of species interactions through satellite remote sensing-based animal count data. Such information affords powerful opportunities to conduct cross-scale investigations of animal distributions and derive mechanistic explanations for observed patterns of habitat selection in a changing environment. For instance, these tools can facilitate studies of animal occurrence in response to an array of previously undetected environmental features, including spatially explicit distributions of conspecifics and heterospecifics, and the understudied role of microhabitats in resource selection by large wildlife (Hughey et al., 2018).

In the case of Point Reyes, satellite technology holds additional promise as a tool for the rapid assessment of disease risk in areas shared by elk and cattle. Specifically, the spread of 'Johne's disease' (*Mycobacterium avium paratuberculosis*) presents a unique opportunity to better understand how remote sensing might inform disease management in landscapes shared between elk and cattle. This incurable bacterial infection can be transmitted through ingestion of contaminated food or water and affects the small intestine of both wild and domestic ruminants, often with fatal consequences (Chiodini et al., 1984). While there is no public information on infection rates in cattle of Point Reyes, Johne's can persist in the environment for more than a year (Elliott et al., 2015) and has been documented in the study herd as recently as 2016 (Bernot and Press, 2018). As a result, it is important to continue to monitor changes in spatial overlap between the two species as part of a larger monitoring program, which includes additional testing and ground-based observations that account for site-specific interactions between contact rates, vaccine performance, host susceptibility, and the presence of other wildlife reservoirs (Gerritsmann et al., 2014; Knust et al., 2011).

While we caution that sufficient satellite coverage may not be feasible for many ecosystems (especially in forested or cloudy environments), a growing body of literature demonstrates the fresh promise of such methods for conducting large-scale biological monitoring in a variety of environmental contexts (e.g., LaRue et al., 2017) Pettorelli et al., 2014; Wang et al., 2019). Moreover, imminent advances in satellite imaging technology (e.g., increased spatiotemporal resolution, low-cost CubeSats, and democratization of AI technology) are rapidly reducing historic barriers to data access. Such developments will enhance our ability to study the ecology of open landscapes with precision and facilitate access to remote ecosystems around the world (Hughey et al., 2018; Weinstein, 2018).

5. Conclusions

Developing an in-depth understanding of how imperiled wildlife use the environments into which they have been reintroduced is a critical but often overlooked component of conservation. In this study, we evaluated the drivers of habitat selection by a native ungulate that was reintroduced to active rangelands defined by the year-round presence of cattle. We have used multiple, complementary data streams to reveal that cattle are the dominant drivers of habitat selection by reintroduced elk and that elk avoid cattle when possible (at large scales) and partition resources when necessary (at fine scales) in order to access limited grazing opportunities. Together, our three approaches have indicated the scale-dependent dynamics of habitat selection by a native ungulate and revealed new insights into elk-cattle interactions. In addition, contrary to common assumptions, our results indicate that native elk minimize their interactions with cattle and thus, in this ecosystem, grazing conflicts between wildlife and livestock may be limited.

Data availability statement

Code and data for all analyses presented in this paper are available on GitHub: https://github.com/kevintshoemaker/PRNS_Elk.

CRediT authorship contribution statement

Lacey Hughey: Conceptualization, Methodology, Formal Analysis, Data Curation, Writing- Original Draft, Review, & Editing, Visualization, Project Administration, Funding Acquisition. **Kevin Shoemaker**: Methodology, Software, Validation, Formal Analysis, Data Curation, Writing Original Draft, Review, & Editing, Visualization. **Kelley Stewart**: Methodology, Software, Formal Analysis, Writing Original Draft, Review, & Editing, Visualization. **Douglas McCauley**: Methodology, Writing- Review & Editing, Supervision, Funding Acquisition. **Hall Cushman**: Conceptualization, Writing- Review & Editing, Supervision, Project Administration, Funding Acquisition.

Declaration of competing interest

Lacey Hughey was an employee of Point Reyes National Seashore prior to development of this publication (2009–2014).

Acknowledgements

We thank David Press and Tim Bernot of Point Reyes National Seashore (NPS) for collection and management of all datasets. We also thank Dr. Benjamin Becker (NPS), Dr. Peter Gogan (USGS), and one anonymous reviewer for comments on early drafts of the manuscript. This work was supported by grants from the U. S. National Park Service, the National Science Foundation, and the DigitalGlobe Foundation.

Appendix A. Chemical immobilization and GPS collar deployment details

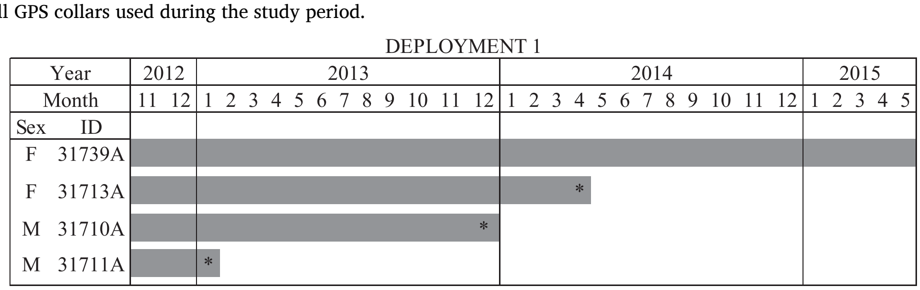
Table A1
Chemical immobilization details for elk captured during the study period. Seven animals were fitted with GPS collars from Advanced Telemetry Systems (GS110E/E2 Iridium, Minnesota, USA) and one (ID 24034B) was fitted with a Vectronics collar (Vertex Lite Iridium 2D GPS, Berlin, Germany). All animals were captured according to protocols approved by the National Park Service Institutional Animal Care and Use Committee (Protocol: PWR_PORE_PRESS_TULE_2012) and following established guidelines (Sikes and Animal Care and Use Committee of the American Society of Mammalogists, 2016).

Sex	Weight (kg)	2012 Immobilization	2012 Reversal	2013–2017 Immobilization	2013–2017 Reversal
Female	180	3 ml mixture of: 3 mg/kg Telazol 1.3 mg/kg xylazine	36 mg (3.6 ml 10 mg/ml yohimbine)	2.0 ml pre-mixed BAM: 54.6 mg butorphanol 18.2 mg azaperone 21.8 mg medetomidine	200 mg (1.0 ml 200 mg/ml tolazoline) 50 mg (1.0 ml 50 mg/ml naltrexone) 65 mg (2.6 ml 25 mg/ml atipamazole)
Male	250	4 ml mixture of: 3 mg/kg Telazol 1.3 mg/kg xylazine	50 mg (5.0 ml 10 mg/ml yohimbine)	3.0 ml pre-mixed BAM: 81.9 mg butorphanol 27.3 mg azaperone 32.7 mg medetomidine	200 mg (1.0 ml 200 mg/ml tolazoline) 50 mg (1.0 ml 50 mg/ml naltrexone) 100 mg (4.0 ml 25 mg/ml atipamazole)

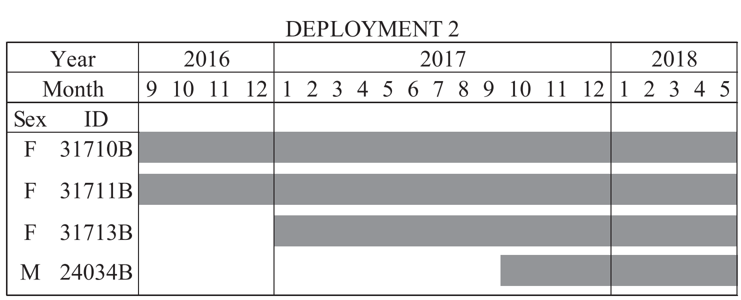
References

Sikes, R.S., Animal Care and Use Committee of the American Society of Mammalogists, 2016. 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. J. Mammal. 97, 663–688. https://doi.org/10.1093/jmammal/gyw078

Table A2
Deployment schedule for all GPS collars used during the study period.



* Collar loss or failure



Appendix B. Coefficient values & interaction plots from Resource Selection Function analysis

Table B1

Summary values for all coefficients retained in top models. *Collar*: modeled from GPS collar data collected at Point Reyes National Seashore from November 2012 to March 2018 (see Appendix A for details). *Count and P(1+)*: Modeled from visual surveys conducted at Point Reyes National Seashore from September 2010 to November 2017. *Count* represents probability that elk abundance will increase as a function of each covariate. *P(1+)* represents probability of elk presence (one or more elk observed) as a function of each covariate.

		Collar		Count		P(1+)	
Variable	Season	Estimate	SE	Estimate	SE	Estimate	SE
Cattle Density	Mating	−4.08	1.48	NA	NA	NA	NA
Cos Aspect	Mating	−0.19	0.17	NA	NA	NA	NA
Dist to Pond	Mating	−0.34	1.19	−0.42	0.32	0.85	0.34
Elevation	Mating	0.91	0.72	NA	NA	NA	NA
High Intensity Ag	Mating	−0.29	1.04	NA	NA	NA	NA
Moist Grassland (%)	Mating	0.55	0.15	0.05	0.27	0.22	0.33
NDVI	Mating	−0.15	0.31	−0.07	0.2	0.23	0.36
NDVI*CattleDensity	Mating	NA	NA	NA	NA	NA	NA
NDVI*MoistGrass	Mating	−0.16	0.27	−1.35	0.41	0.28	0.58
NDVI*Scrub	Mating	−1.56	0.32	NA	NA	NA	NA
Pasture	Mating	0.72	1.68	−0.73	0.19	0.42	0.3
Scrub (%)	Mating	−0.19	0.38	−0.64	0.35	0.2	0.36
Slope	Mating	−1.5	0.38	NA	NA	NA	NA
Slope*CosAspect	Mating	−0.62	1.31	NA	NA	NA	NA
Cattle Density	Parturition	−0.73	0.44	0.3	0.12	0.15	0.35
Cos Aspect	Parturition	−1.26	0.14	−0.44	0.18	1.01	0.37
Dist to Pond	Parturition	−0.76	0.16	NA	NA	NA	NA
Elevation	Parturition	1.02	0.48	−0.42	0.16	−1.24	0.39
High Intensity Ag	Parturition	0.16	0.14	0.37	0.15	−0.6	0.4
Moist Grassland (%)	Parturition	−0.18	0.06	NA	NA	NA	NA
NDVI	Parturition	0.62	0.14	NA	NA	NA	NA
NDVI*CattleDensity	Parturition	NA	NA	NA	NA	NA	NA
NDVI*MoistGrass	Parturition	0.38	0.25	NA	NA	NA	NA

		Collar	Count	P(1+)			Collar
Variable	Season	Estimate	SE	Estimate	Variable	Season	Estimate
NDVI*Scrub	Parturition	−0.74	0.46	NA	NA	NA	NA
Pasture	Parturition	−1.12	0.47	0.05	0.13	1.32	0.34
Scrub (%)	Parturition	−0.26	0.21	NA	NA	NA	NA
Slope	Parturition	−0.66	0.08	NA	NA	NA	NA
Slope*CosAspect	Parturition	0.59	0.24	NA	NA	NA	NA
Cattle Density	Summer	NA	NA	NA	NA	NA	NA
Cos Aspect	Summer	−0.52	0.05	−0.19	0.35	1.04	0.33
Dist to Pond	Summer	−1	0.37	−0.39	0.37	1.33	0.35
Elevation	Summer	0.07	0.17	−1.1	0.33	−0.19	0.3
High Intensity Ag	Summer	0.08	0.43	NA	NA	NA	NA
Moist Grassland (%)	Summer	0.32	0.14	NA	NA	NA	NA
NDVI	Summer	−1.04	0.21	−3.51	3.13	0.17	0.4
NDVI*CattleDensity	Summer	−3.71	0.49	−15.1	14.16	1.27	0.91
NDVI*MoistGrass	Summer	0.13	0.16	NA	NA	NA	NA
NDVI*Scrub	Summer	−0.96	0.13	NA	NA	NA	NA
Pasture	Summer	−1.01	0.18	NA	NA	NA	NA
Scrub (%)	Summer	−0.17	0.14	−0.79	0.47	0.35	0.37
Slope	Summer	−0.94	0.15	0.25	0.32	0.83	0.34
Slope*CosAspect	Summer	0.4	0.35	2.42	0.9	1.15	0.68
Cattle Density	Wet	−0.79	0.32	NA	NA	NA	NA
Cos Aspect	Wet	−0.9	0.06	−0.2	0.18	0.63	0.27
Dist to Pond	Wet	−0.34	0.15	NA	NA	NA	NA
Elevation	Wet	1.07	0.32	−0.01	0.18	−1.13	0.29
High Intensity Ag	Wet	0.71	0.26	NA	NA	NA	NA
Moist Grassland (%)	Wet	−0.12	0.12	NA	NA	NA	NA
NDVI	Wet	2.28	0.18	−0.48	0.25	0.03	0.41
NDVI*CattleDensity	Wet	NA	NA	NA	NA	NA	NA
NDVI*MoistGrass	Wet	−0.21	0.18	NA	NA	NA	NA
NDVI*Scrub	Wet	0.53	0.17	−0.46	0.84	2.8	1.2
Pasture	Wet	−1.71	0.59	−0.08	0.16	0.96	0.29
Scrub (%)	Wet	0.14	0.32	−0.49	0.37	0.93	0.47
Slope	Wet	−0.42	0.13	NA	NA	NA	NA
Slope*CosAspect	Wet	−0.01	0.21	NA	NA	NA	NA

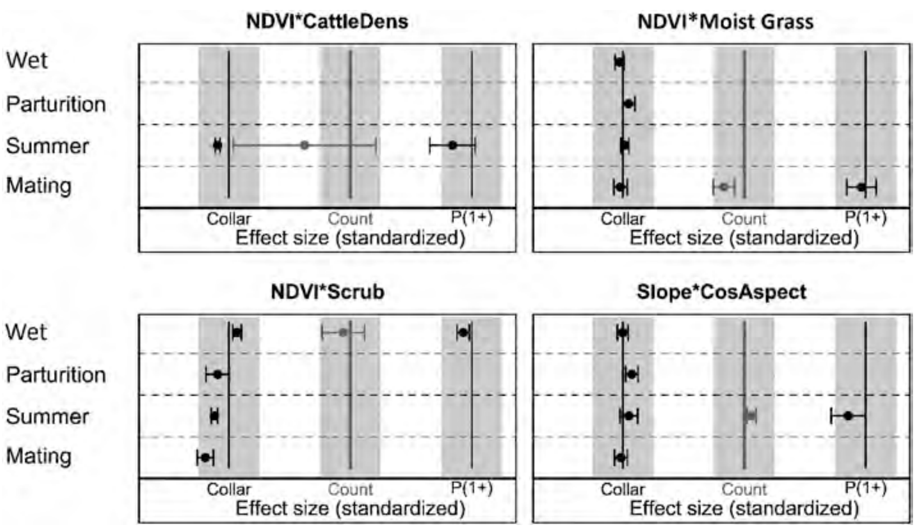


Fig. B1. Interactions between covariates related to patterns of habitat selection by tule elk. Vertical lines indicate an effect size of zero, and gray regions represent (standardized) effect sizes between −2 and 2. *Collar*: modeled from GPS collar data collected at Point Reyes National Seashore from November 2012 to March 2018 (see Appendix A for details). *Count and P(1+)*: Modeled from visual surveys conducted at Point Reyes National Seashore from September 2010 to November 2017. *Count* represents probability that elk abundance will increase as a function of each covariate. *P(1+)* represents probability of elk presence (one or more elk observed) as a function of each covariate. Error bars represent 1 standard error (s.e).

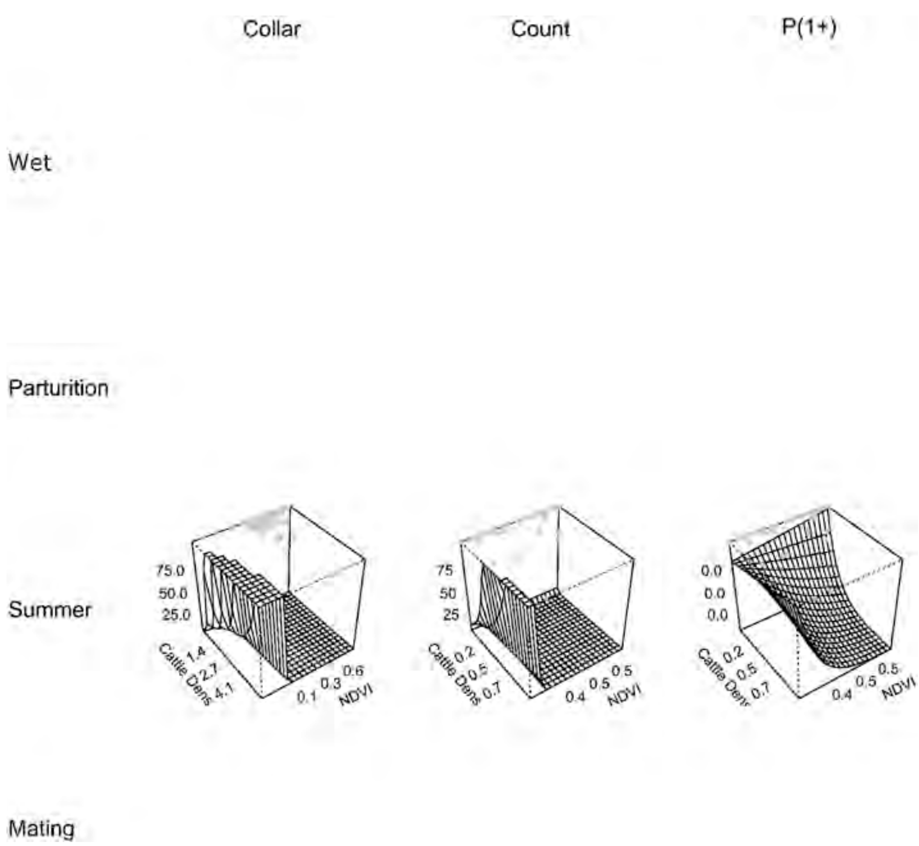


Fig. B2. Interaction between cattle density (Cattle Dens) and NDVI for predicting elk habitat selection. *Collar*: modeled from GPS collar data collected at Point Reyes National Seashore from November 2012 to March 2018 (see Appendix A for details); y axis represents selection intensity. *Count and P(1+)*: Modeled from visual surveys conducted at Point Reyes National Seashore from September 2010 to November 2017. *Count* represents probability that elk abundance will increase as a function of each covariate; y axis represents density at a survey point. *P(1+)* represents probability of elk presence (one or more elk observed) as a function of each covariate; y axis represents the probability of observing one or more elk at a survey point. Gray dots represent raw data, which is clustered at high NDVI values and low cattle densities. As a result, the apparent relationship between low cattle densities and low NDVI should be interpreted with caution. Blank panels denote that this interaction was not included in the top model for a particular season/model combination.

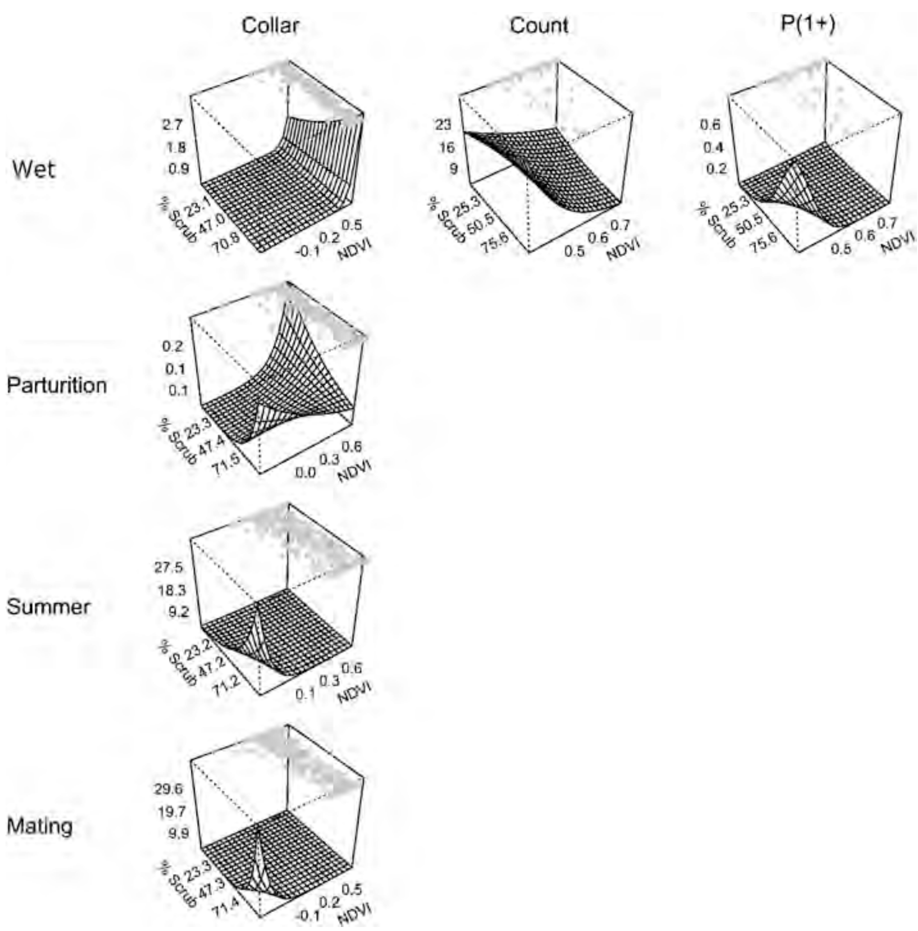


Fig. B3. Interaction between scrub vegetation and NDVI for predicting elk habitat selection. *Collar*: modeled from GPS collar data collected at Point Reyes National Seashore from November 2012 to March 2018 (see Appendix A for details); y axis represents selection intensity. *Count and P(1+)*: Modeled from visual surveys conducted at Point Reyes National Seashore from September 2010 to November 2017. *Count* represents probability that elk abundance will increase as a function of each covariate; y axis represents density at a survey point. *P(1+)* represents probability of elk presence (one or more elk observed) as a function of each covariate; y axis represents the probability of observing one or more elk at a survey point. Gray dots represent raw data and blank panels denote that this interaction was not included in the top model for a particular season/model combination.

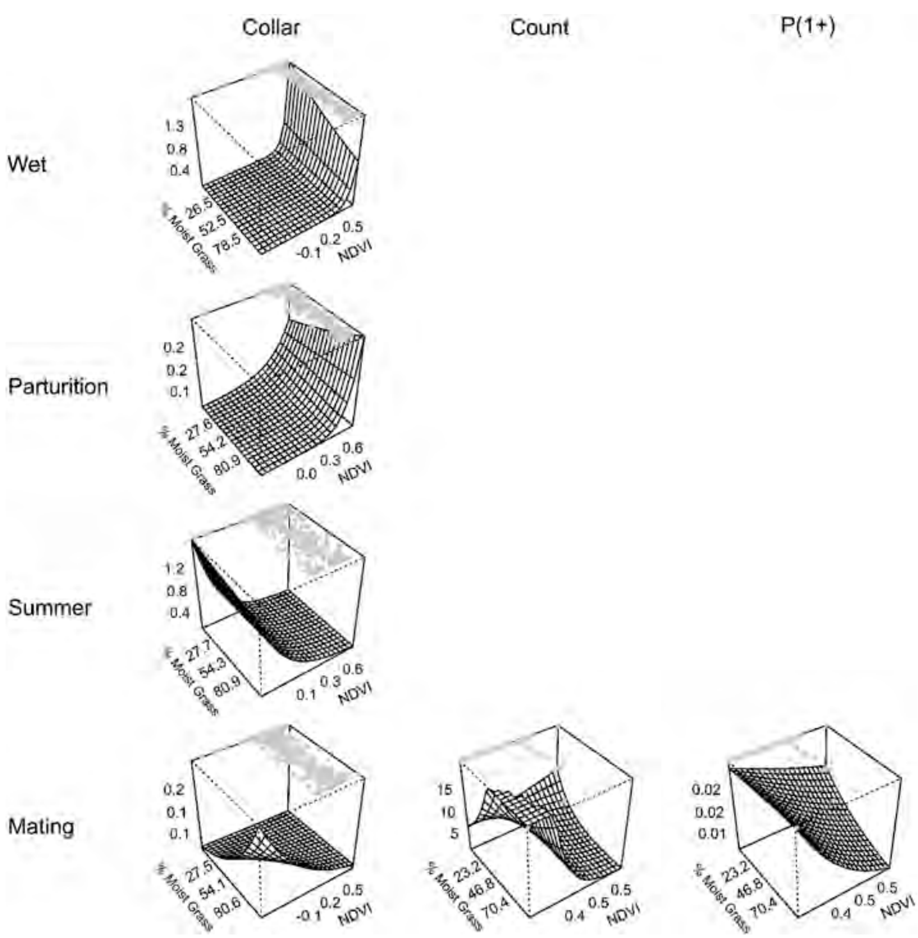


Fig. B4. Interaction between moist grasslands and NDVI for predicting elk habitat selection. *Collar*: modeled from GPS collar data collected at Point Reyes National Seashore from November 2012 to March 2018 (see Appendix A for details); y axis represents selection intensity. *Count and P(1+)*: Modeled from visual surveys conducted at Point Reyes National Seashore from September 2010 to November 2017. *Count* represents probability that elk abundance will increase as a function of each covariate; y axis represents density at a survey point. *P(1+)* represents probability of elk presence (one or more elk observed) as a function of each covariate; y axis represents the probability of observing one or more elk at a survey point. Gray dots represent raw data and blank panels denote that this interaction was not included in the top model for a particular season/ model combination.

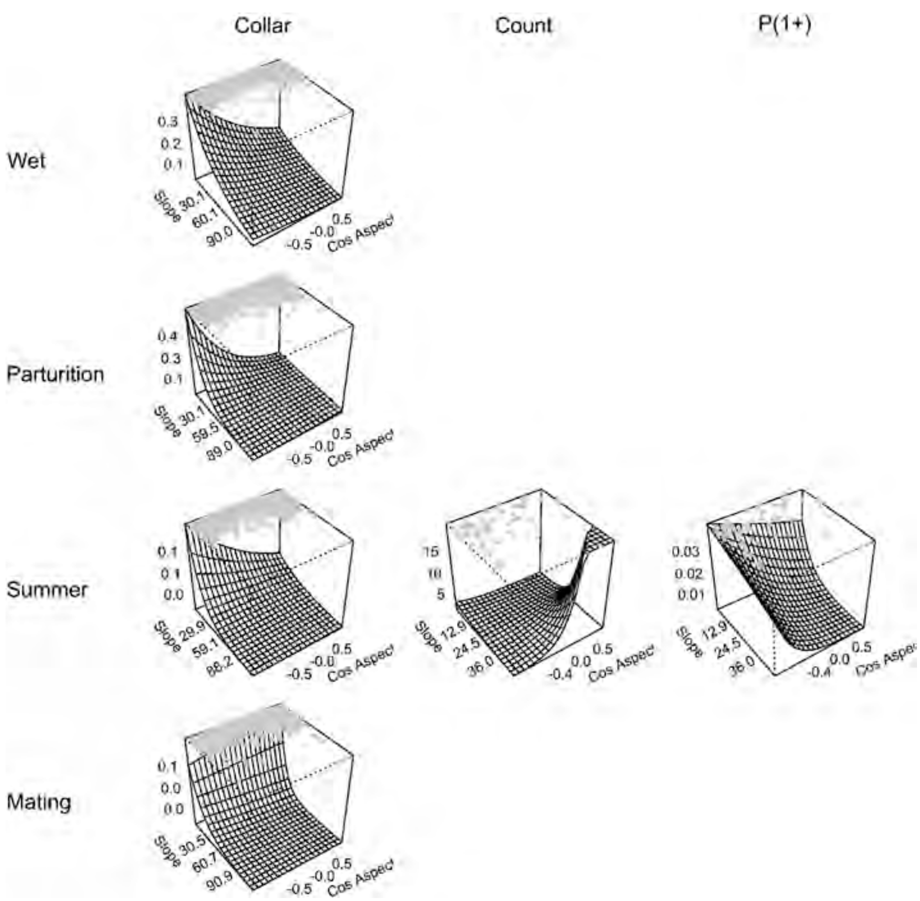


Fig. B5. Interaction between slope and 'northness' (cos aspect) for predicting elk habitat selection. *Collar*: modeled from GPS collar data collected at Point Reyes National Seashore from November 2012 to March 2018 (see Appendix A for details); y axis represents selection intensity. *Count and P(1+)*: Modeled from visual surveys conducted at Point Reyes National Seashore from September 2010 to November 2017. *Count* represents probability that elk abundance will increase as a function of each covariate; y axis represents density at a survey point. *P(1+)* represents probability of elk presence (one or more elk observed) as a function of each covariate; y axis represents the probability of observing one or more elk at a survey point. Gray dots represent raw data and blank panels denote that this interaction was not included in the top model for a particular season/ model combination.

Appendix C. Satellite remote sensing-based species detections

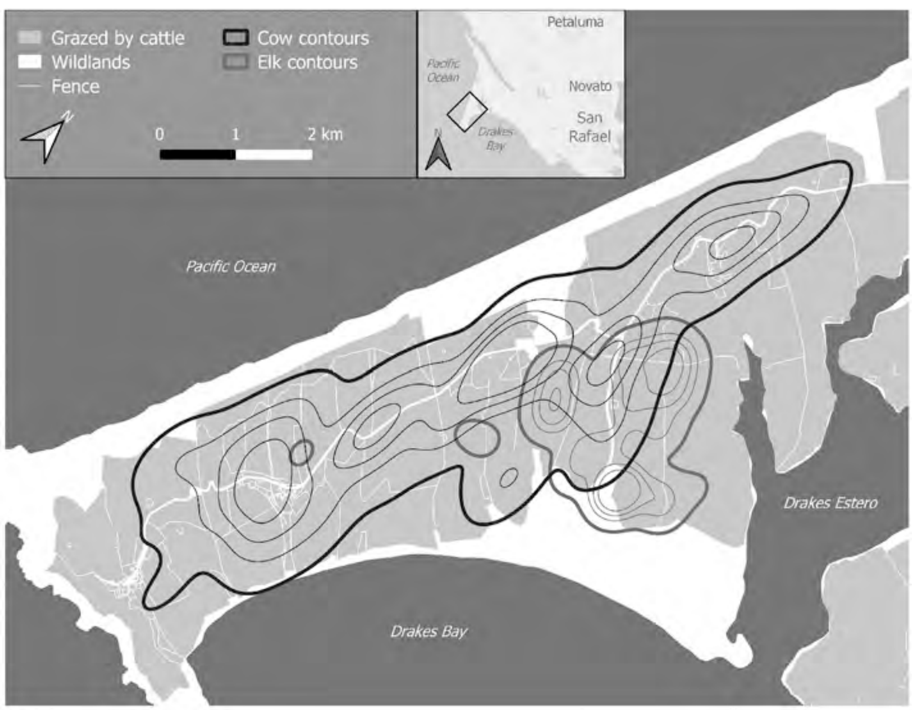


Fig. C1. Range overlap between elk and cattle within grazed pastures. Contours were created from satellite remote sensing-based animal detections (within grazed pastures only) and represent kernel density isopleths (95% contours bolded) for elk and cattle (n = 28, images from 2014 to 2018).

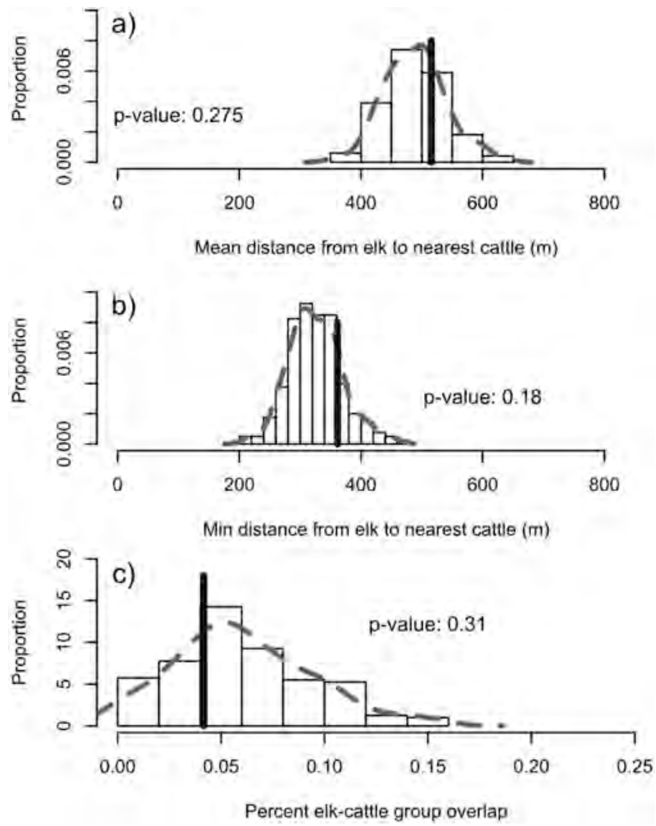


Fig. C2. Semi-parametric bootstrap tests of elk and cattle distributions obtained from satellite images. Observed metrics of elk-cattle spatial separation (thick vertical black lines) and the null distributions of these metrics (histograms; assuming elk locations were unrelated to cattle locations) are presented. Panels depict (a) mean distances from each randomly sampled elk location to the nearest cattle location, averaged across images; (b) minimum elk-cattle distances averaged across images; (c) the proportion of elk-cattle co-occurrences (defined as the fraction of elk groups for which any members were within 50 m of a cattle location), averaged across all images ($n = 28$).

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Paratuberculosis in Tule Elk in California

PARATUBERCULOSIS WAS diagnosed in 3 tule elk *(Cervus elaphus nannodes)* in the winter of 1980 and the spring of 1981. The diagnosis was based on gross necropsy and histopathologic findings and on isolation of *Mycobacterium paratuberculosis* from tissues and feces of the 3 elk. Fecal culture and acid-fast stains of fecal smears proved to be more effective than complement fixation in diagnosis of the disease.

Paratuberculosis has been reported in numerous captive wild species, including white-tailed deer *(Odocoileus virginianus)*,[1] roe deer *(Capreolus capreolus)*,[2] European red deer *(Cervus elaphus)*,[3,4] moose *(Alces alces)*,[5] aodad *(Ammotragus lervia)*,[6] mouflon *(Ovis musimon)*,[4,6] camel *(Camelus bactrianus)*,[4,7] bighorn sheep *(Ovis canadensis)*,[7] reindeer *(Rangifer tarandus)*,[4] Japanese sika deer *(Sika nippon)*,[4] water buffalo *(Bubalus bubalus)*,[4] yak *(Bos grunniens)*,[4] gnu *(Connochaetes albojubatus)*,[4] and llama *(Lama glama)*.[8]

Reports of clinical paratuberculosis in free-ranging wildlife are few and incomplete, except for a recent report of 6 cases involving a herd of Rocky Mountain bighorn sheep and a Rocky Mountain goat *(Oreamnos americanus)* on Mt. Evans, Colo.[9] In the present report, we document 3 clinical cases of paratuberculosis in a herd of tule elk *(Cervus elaphus nannodes)* recently established on land previously used by dairy and beef cattle. Subclinical infection was diagnosed in a 4th animal.

At Point Reyes on the coast of central California, the National Park Service maintains a reservation of approximately 100,000 acres on a peninsula jutting into the Pacific Ocean (Fig 1). Several of the original family dairy farms

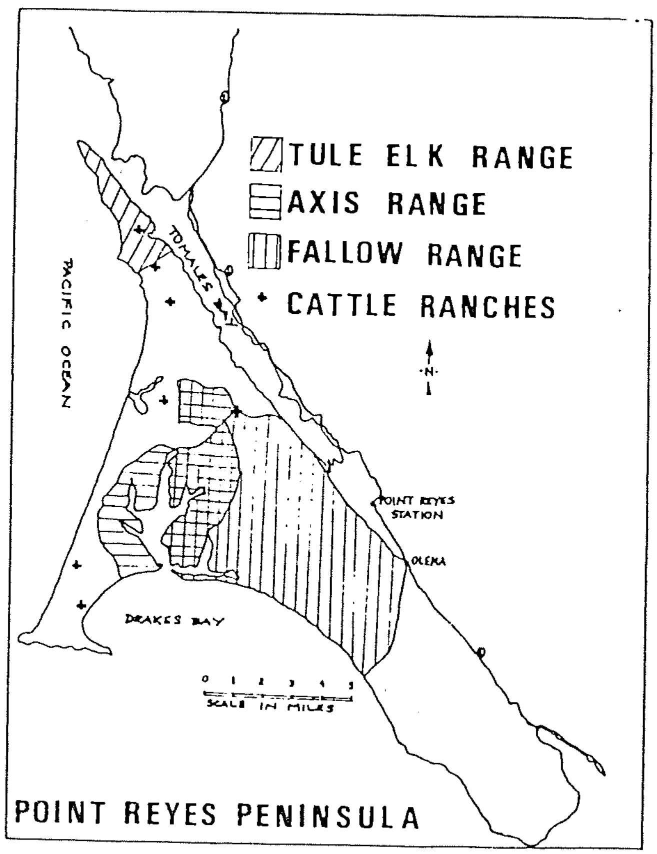

Fig 1—Map of Point Reyes National Seashore, showing locations of exotic deer, dairy cattle, and tule elk. Black-tailed deer use the entire peninsula.

throughout the area are operated through lease arrangements with the Park Service. Two species of exotic deer, axis deer *(Axis axis)* and fallow deer *(Dama dama)*, were introduced into the area during the 1940s. Since their introduction, the exotic deer population has increased to the extent that

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control measures are necessary to maintain populations at carrying capacity. Although *M paratuberculosis* had been isolated from feces of normal axis and fallow deer at Point Reyes, none was clinically affected with paratuberculosis.[10] Tule elk were introduced onto the peninsula in 1978 in accordance with state laws granting them full protection and mandating relocation of tule elk onto historic ranges. Contact between exotic deer and tule elk has not occurred.

The 3 affected tule elk were born at the Point Reyes National Seashore after relocation of a herd of 14 adult elk to the narrow end of the peninsula, separated by fencing from dairy farms. Two were born in March 1978, one in March 1979. Due to ongoing litigation, beef cattle remained on the elk range for over a year, severely competing for feed. Copper deficiency and starvation resulted in the deaths of several adult elk, and reproductive rates were greatly reduced until cattle were removed. Although transient diarrhea is a common spring phenomenon in wild ruminants, two 2-year-old elk had diarrhea through the summer and into the fall of 1980. Because California law protects tule elk, it was decided to immobilize and test affected animals and as many others in the herd as possible.

A combination of 4 mg of etorphine[11] and 35 mg of xylazine[12] was administered via dart syringe to 12 animals. Venous blood samples and fecal samples were obtained from 12 individuals. Animal 1 was presented for necropsy on Nov 25, 1980, and provided the initial diagnosis. Animals 2 and 3 were euthanatized in extremis in March and May 1981, respectively. Feces from each live animal and mesenteric lymph nodes from each necropsy were stained by the Ziehl-Neelsen method. Representative tissue specimens were fixed in buffered 10% formalin, routinely processed, and stained with hematoxylin and eosin and Ziehl-Neelsen stains. Blood samples were allowed to clot, then refrigerated and separated for serum. Serums were tested for antibodies against *M paratuberculosis,* using the complement-fixation test. Fecal and tissue specimens were washed in 0.3% benzalkonium chloride,[13] as outlined by Merkal.[14] A 1.0-ml aliquot of each fecal suspension or tissue homogenate was inoculated onto slants of Herrold's egg medium with mycobactin and onto 1 slant without mycobactin.[14] Incubation times ranged from 12 to 14 weeks at 37 C. Diagnosis was based on microscopic examination of clumps of acid-fast bacilli from colonies subinoculated to additional slants that had mycobactin dependence.

Initially, clumps of acid-fast organisms were identified in the feces of the clinically affected animals. *Mycobacterium paratuberculosis* was eventually recovered from these animals, as well as from a 4th animal that appeared normal and had a fecal smear negative for acid-fast bacteria. Complement-fixation testing revealed little difference between fecal culture-positive and fecal culture-negative animals. Two of 10 fecal culture-negative animals had no reaction; the rest had suspect reactions of 1:8. Animal 2 retested at necropsy had a titer of 1:32. *Mycobacterium paratuberculosis* was recovered from feces and mesenteric lymph nodes of all 3 affected animals, and from liver and gut sections of animal 2. Affected animals had similar gross and microscopic lesions. All 3 animals were emaciated, had fecal pasting of the hocks and perineum, and had rough, light-colored, brittle coats. All animals had subserosal edema of the jejunum and ileum and attaching mesentery. Afferent lymphatics from this region were enlarged, beaded, and cream-colored. Mesenteric lymph nodes draining this area were firm and, on cross section, white proliferative patches were noticed. The walls of the jejunum and proximal ileum were extremely thickened and rugose, and the mucosal surfaces were reddened. Multiple 1- to 2-cm light-colored areas were present throughout the liver of animal 2.

Microscopic examination of the lamina propria and submucosa of the jejunum and proximal ileum revealed extensive infiltration by large, pale, foamy eosinophilic epithelioid mononuclear inflammatory cells. The distal ileum and cecum were less severely affected. Acid-fast organisms, usually within macrophages, were evident in the lamina propria and submucosa. Multinucleated giant cells were in the submucosa and mesenteric lymph nodes. Although granuloma formation was a prominent feature of the

inflammatory response, caseation, necrosis, and mineralization were not seen. Small granulomata were scattered through the liver of animal 2 in a pattern suggesting vascular metastasis.

Spores of *M paratuberculosis* can survive for over a year,[15] and cattle on the premises during or shortly before elk relocation seem the most likely source of infection. How important a role marginal nutrition during the 1st year of life played in susceptibility to infection should become evident as future generations of tule elk are born at Point Reyes without competition with cattle. It should be noted that tule elk are a highly inbred race or subspecies of elk. Immunologic competence of tule elk has not been tested or compared with that of other races of elk or domestic animals. The clinical and pathologic features of paratuberculosis in tule elk most closely resemble the disease in domestic cattle. Microscopically, mineralization or caseation was not evident in the intestinal wall or lymph nodes, as described in affected domestic sheep.[16,17] Giant cell formation, as reported in cattle, was abundant in the intestinal wall and in lymphatic tissues. Although naturally occurring paratuberculosis has not been reported in free-ranging elk, it has been reported in several closely related species and has been transmitted experimentally to elk.[18]—*David A. Jessup, DVM, Wildlife Investigations Laboratory, California Department of Fish and Game, 1701 Nimbus Rd, Rancho Cordova, CA 95670; Babiker Abbas, DVM, MPVM, and Darrell Behymer, BS, School of Veterinary Medicine, University of California, Davis, CA 95616; and Peter Gogan, MS, University of California, Berkeley, CA 94720.*

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Influence of a Large Herbivore Reintroduction on Plant Invasions and Community Composition in a California Grassland

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Abstract: *Despite many successful reintroductions of large mammalian herbivores throughout the world, remarkably little attention has focused on how these actions affect native and exotic vegetation at reintroduction sites. One such herbivore is tule elk (*Cervus elaphus nannodes*), which was on the brink of extinction in the mid 1800s, but now has numerous stable populations due to intensive reintroduction efforts. Here, we summarize results from a 5-year exclosure experiment that explored the effects of tule elk on a coastal grassland in northern California. Elk significantly altered the species composition of this community; the response of annual species (dominated heavily by exotic taxa) was dramatically different from perennial species. Elk herbivory increased the abundance and aboveground biomass of native and exotic annuals, whereas it either had no effect on or caused significant decreases in perennials. Elk also decreased the cover of native shrubs, suggesting that these herbivores play an important role in maintaining open grasslands. In addition, elk significantly reduced the abundance and biomass of a highly invasive exotic grass,* Holcus lanatus, *which is a major problem in mesic perennial grasslands. Our results demonstrate that the successful reintroduction of a charismatic and long-extirpated mammal had extremely complex effects on the plant community, giving rise to both desirable and undesirable outcomes from a management perspective. We suspect that these kinds of opposing effects are not unique to tule elk and that land managers will frequently encounter them when dealing with reintroduced mammals.*

Keywords: coastal grasslands, herbivory, plant functional groups, plant invasions, reintroduced mammals, shrub encroachment, tule elk

Influencia de la Reintroducción de un Herbívoro Mayor sobre Invasiones de Plantas y la Composición de la Comunidad en un Pastizal de California

Resumen: *A pesar de muchas reintroducciones exitosas de grandes mamíferos herbívoros en todo el mundo, notablemente se ha puesto poca atención en como estas acciones afectan a la vegetación nativa y exótica en los sitios de reintroducción. Uno de tales herbívoros es el alce (*Cervus elaphus nannodes*), que estaba a punto de extinguirse a mediados del siglo XIX, pero que ahora tiene numerosas poblaciones estables debido a esfuerzos intensivos de reintroducción. Aquí, resumimos los resultados de un experimento de exclusión de 5 años que exploró los efectos de alces sobre un pastizal costero en el norte de California. Los alces alteraron significativamente la composición de especies de esta comunidad; la respuesta de especies anuales (dominadas ampliamente por taxa exóticos) fue dramáticamente diferente a la de especies perennes. La herbivoría de alces incrementó la abundancia y biomasa de anuales nativas y exóticas, mientras que no tuvo efecto o no causó disminuciones significativas en las perennes. Los alces también disminuyeron la cobertura arbustos nativos, lo que sugiere que estos herbívoros juegan un papel importante en el mantenimiento de los pastizales abiertos. Adicionalmente, los alces significativamente redujeron la abundancia y biomasa de un pasto exótico*

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altamente invasivo, Holcus lanatus, *que es un problema mayor en los pastizales mésicos perennes. Nuestros resultados demuestran que la reintroducción exitosa de un mamífero carismático tuvo efectos extremadamente complejos sobre la comunidad de plantas, dando lugar a consecuencias tanto deseables como indeseables desde una perspectiva de manejo. Sospechamos que estos tipos de efectos opuestos no son exclusivos de alces y que los gestores los enfrentaran frecuentemente cuando traten con mamíferos reintroducidos.*

Palabras Clave: alce, grupos funcionales de plantas, herbivoría, invasión de arbustos, invasiones de plantas, mamíferos reintroducidos, pastizales costeros

Introduction

For thousand of years the abundance and distribution of large mammalian herbivores have been modified greatly by human activity (Martin & Klein 1984), and these effects increased substantially with European colonization of North America and other regions of the world (Naiman 1988; Knapp et al. 1999). During the past century programs were initiated to reintroduce extirpated mammals into parts of their historical range (Nielsen & Brown 1988), and many of these taxa have increased in numbers due to such conservation efforts (Noss 2001).

Extensive research has been conducted on herbivore populations to better understand how they respond to reintroduction (Nielsen & Brown 1988; Griffith et al. 1989; Noss 2001), but remarkably little is known about the effects of these long-absent taxa on recipient ecosystems (i.e., ecosystems into which species have been reintroduced). This is surprising, given that the results of many studies show that large mammalian herbivores can have substantial impacts on the composition and structure of plant communities (e.g., Crawley 1983; Huntly 1991; Knapp et al. 1999). How communities respond to the reintroduction of previously extirpated herbivores will be determined to some extent by the unfortunate reality that recipient ecosystems have been modified in many ways other than the loss of a dominant herbivore. For example, herbivore populations are commonly reintroduced into ecosystems that have been invaded heavily by exotic plant species (e.g., Vitousek et al. 1996; Mack et al. 2000; Mooney & Hobbs 2000). Native herbivores may negatively influence exotic plants by reducing their biomass, fecundity, and/or abundance in communities or they may avoid exotic plants and feed on only native hosts, thereby promoting the success of exotics by reducing the dominance of native species and freeing up resources that invaders can exploit (e.g., Davis et al. 2000; Maron & Vila 2001; Levine et al. 2004). Thus, it will be critical to understand if and how reintroduced herbivores affect the success of plant invaders and the structure and composition of communities.

The effects of reintroduced herbivores on plant communities will be determined in part by the life history characteristics and geographic origins of resident species present in the community. Plants from different functional groups may vary greatly in their response to herbivory, as might native and exotic taxa within the same functional group. In addition, these herbivores may keep grasslands open by slowing or even preventing the encroachment of woody species. Furthermore, native shrubs in grasslands may alter the effects of herbivores on herbaceous plants in the system. For these reasons it will be critical to conduct studies that take a community approach and assess how reintroduced herbivores influence native and exotic taxa with different suites of life history characteristics.

Grasslands throughout California have undergone an extraordinary transformation over the past 200 years. Once dominated by native perennial bunchgrasses, they are now composed primarily of annual grasses from Eurasia (Heady 1988; Heady et al. 1988; 1992). Accompanying these changes has been a precipitous decline in mammalian herbivores and an increase in domesticated grazers (Wagner 1989). Like many large herbivores, populations of tule elk (*Cervus elaphus nannodes*) in California suffered rapid decline soon after the arrival of European settlers, going from an estimated 500,000 animals in 1769 to fewer than 10 individuals 70 years later (Phillips 1976; Toweill & Thomas 2002). By 1986 numbers had increased to over 2000 individuals distributed among 22 populations throughout California, largely due to successful reintroduction programs (McCullough et al. 1996). Tule elk thus provide an ideal opportunity to study the influence of herbivore reintroductions on a highly altered recipient grassland.

Here, we used a 5-year exclosure experiment to address four questions concerning the influence of reintroduced tule elk on a coastal grassland in northern California: (1) Does herbivory by reintroduced tule elk influence the abundance, species richness, and aboveground biomass of different plant functional groups in grassland communities that vary in shrub abundance? (2) Do native and exotic plant taxa vary in their responses to elk reintroduction? (3) Do tule elk deter the encroachment of shrubs into this grassland system? and (4) Can a dominant exotic grass escape herbivory by associating with a native shrub? We predicted that the reintroduction of tule elk would reduce the prevalence of shrubs in the grassland, decrease the prevalence of perennial grasses and forbs, and promote the success of annual species, which are

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dominated heavily by exotic taxa. Our results should provide insight into the effects of a reintroduced native herbivore on the composition of an invaded grassland community and provide land managers with critical information needed for the effective and sustainable management of California grasslands.

Study System

The Tomales Point Elk Reserve is a 1030-ha wilderness area located within Point Reyes National Seashore, approximately 32 km north of San Francisco in Marin County, California. The climate is Mediterranean and typical of California's central coast, with moderate, rainy winters and cool, foggy summers with little rain.

Tule elk have been a dominant feature of all habitat types on Tomales Point since their reintroduction in 1980. Approximately 400 cattle were removed from Tomales Point in 1979, after more than 100 years of grazing (Lathrop & Gogan 1985). Within a year of the cattle removal, eight female and two male tule elk were reintroduced to the point from a population in the San Luis Island Wildlife Refuge near Los Banos, in central California (Lathrop & Gogan 1985). The elk population increased to 93 individuals by 1988 and to approximately 500 individuals by 2003 (N. Gates, personal communication). The diet of tule elk at Tomales Point consists primarily of herbaceous forbs and grasses, but they also consume shrub foliage during the winter months when there is less herbaceous material available (Gogan & Barrett 1995).

The vegetation of Tomales Point consists primarily of a mosaic of shrub-dominated coastal scrub and grassland, interrupted by steep canyons and swales containing dense riparian shrubs (Lathrop & Gogan 1985). We focused on the grassland component of Tomales Point, which consists of a diverse assemblage of both native and introduced herbaceous plant species intermixed with native shrubs. Three distinct grassland types occurred within the 300-ha study area: *Baccharis*-dominated grassland, *Lupinus*-dominated grassland, and open grassland. *Baccharis* grasslands were characterized by herbaceous-dominated patches intermixed with dense stands of the native woody shrub, *Baccharis pilularis* DC (coyote bush). *Lupinus* grasslands were located in predominantly open areas interspersed with a native nitrogen-fixing shrub, *Lupinus arboreus* Sims. And the open grasslands were dominated by herbaceous species and nearly devoid of dominant woody shrubs. All three of these vegetation types have a high proportion of herbaceous species overlap.

Herbaceous plant species at Tomales Point can be grouped into one of five functional groups based on life history and phylogenetic characteristics: annual monocots, annual dicots, perennial monocots, perennial dicots, and nonangiosperms (ferns and their allies). Annual and perennial monocots at this site were almost exclusively grasses and included native perennials, such as *Bromus carinatus* Hook. & Arn., *Hordeum brachyantherum* Nevski, and *Danthonia californica* Bolander, and exotic perennials, such as *Lolium perenne* L. and *Holcus lanatus* L. Several species of exotic annual grasses (*Vulpia bromoides* [L.] S.F. Gray, *Aira caryophyllea* L., *Bromus hordeaceus* L., and *Cynosurus echinatus* L.) were also abundant, but we never encountered native annual grasses. Native perennial dicots (e.g., *Achillea millefolium* L. and *Eschscholzia californica* Cham.) and exotic perennial dicots (e.g., *Hypochaeris radicata* L. and *Plantago lanceolata* L.) were all abundant throughout the study area. *Pteridium aquilinum* (L.) Kuhn var. *pubescens* L. Underw. was the only nonangiosperm vascular plant observed in the study area.

Holcus lanatus (velvet grass) is an exotic perennial grass that has invaded many coastal grasslands throughout California. In our site, *Holcus* was abundant in the *Baccharis* grasslands, where it grew underneath shrub canopies and in shrub-free areas (B.E.J., personal observation). This exotic grass occurred less commonly in the open and *Lupinus* grassland types.

Methods

Experimental Design

In 1998 the U.S. National Park Service established an exclosure experiment within a 300-ha study area on Tomales Point to assess the effects of removing reintroduced tule elk on the plant community. Twenty-four 36 × 36 m plots were distributed equally among three grassland habitat types (*Baccharis* grassland, *Lupinus* grassland, and open grassland). Within each of the three vegetation types, there were four pairs of plots, with plots within pairs randomly assigned fencing to exclude elk or left unfenced to serve as controls. The fencing that surrounded each exclosure plot was 2.5-m tall and effectively excluded elk. Smaller herbivores that occur on Tomales Point, such as hares (*Lepus californicus*) and pocket gophers (*Thomomys bottae*), were not affected by the fencing (B.E.J., personal observation). Black-tailed deer (*Odocoileus hemionus columbianus*) were present in small numbers at the site and were able to enter the exclosures, although probably in reduced numbers. We restricted all vegetation sampling to the central 30 × 30 m area of each plot. This provided a 3-m-wide buffer around the perimeter of each plot and reduced possible edge effects caused by fencing.

Plant Community Composition

In May and June 2002 we harvested all aboveground plant biomass from three randomly chosen 25 × 25 cm quadrats in each plot. We restricted harvests to areas in plots that had <5% shrub cover and sorted aboveground living biomass into annual and perennial plant groups. We also collected accumulated dead biomass (thatch) from the quadrats that were in the *Baccharis* and open plots. We dried living and dead biomass at 60° C for a minimum of 48 hours, and weighed the material immediately after removal from the oven. In the spring of 2003 we quantified abundance of all plant species in the 24 plots within six randomly placed 50 × 50 cm quadrats by counting the number of individuals for each species. In addition, we determined the identity of all plant species that occurred in each plot to obtain whole-plot species richness. We grouped plant species according to their geographic origin (i.e., native or exotic) and then placed them into eight functional groups based on life history characteristics: native and exotic annual dicots, exotic annual monocots, native and exotic perennial dicots, native and exotic perennial monocots, and ferns (native annual monocots were absent from the site). We encountered few ferns during sampling, so this group was not analyzed. Plant nomenclature for all sampling and analysis followed Hickman (1993).

Cover and Density of Shrubs

In July and August 2003 we estimated the aerial cover of shrubs in each of the 24 plots with standard line-intercept methods (Bonham 1989). We established five parallel 30-m transects in all plots at 5-m intervals and measured the extent of shrub cover encountered directly below or above the transect to the nearest centimeter. We determined proportion of shrub cover by dividing total length of shrub coverage along each transect by 30 m.

In June 2003 we determined the abundance of *Lupinus arboreus* juveniles and mature shrubs within the central 30 × 30 m area of each *Lupinus* grassland plot. We classified plants as juveniles if they lacked flowers and fruits and had not yet produced any woody material. Because we rarely encountered *Lupinus* shrubs in the open and *Baccharis* grasslands, we did not sample plots from these areas.

Interactions among Elk, *Holcus*, and *Baccharis*

To evaluate the impact of tule elk and a native shrub species on a dominant invasive grass, we quantified the aboveground biomass and abundance of *Holcus lanatus* in areas within plots dominated by *Baccharis* shrubs and in shrub-free areas. We restricted sampling to the eight *Baccharis* plots because *Holcus* and *Baccharis* rarely occurred in the *Lupinus* and open grasslands. In June 2002 we randomly placed three 25 × 25 cm quadrats in shrub-free areas of each plot and three quadrats in areas with >75% aerial cover of living *Baccharis* foliage. In each quadrat we harvested all aboveground living biomass and separated out all living *Holcus* plant material from samples. We then dried the *Holcus* at 60° C for a minimum of 48 hours and weighed the samples immediately after removal from the oven. In June 2003 we determined the abundance of *Holcus* in each of these same *Baccharis* plots, sampling six 50 × 50 cm quadrats in shrub-free areas and six quadrats in sites with >75% aerial cover of living *Baccharis* foliage.

Statistical Analyses

We performed all statistical analyses with SAS 8.2 (SAS Institute, Cary, North Carolina) and PC-ORD 4.2 (MjM Software, Gleneden Beach, Oregon). We used nonmetric multidimensional scaling (NMS or nMDS) analysis to reduce the dimensionality of the data set and visualize community-level treatment effects. We also used multiresponse-blocked permutation procedure (MRBP), a nonparametric randomization version of a blocked multivariate analysis of variance (MANOVA), to statistically assess treatment effects on community structure. We did not include very rare species (taxa occurring in fewer than three plots) in the analyses to reduce the number of null values in the data matrix. We used Sørensen (Bray-Curtis) distance measure in the NMS analysis and Euclidean distance in the MRBP analysis. For the MRBP analysis, we used elk treatment (present or absent) and plot pair (1–12) as our grouping factors.

To determine the influence of elk on different plant functional groups in the three grassland types, we analyzed our data using multifactor MANOVAs, with elk treatment (elk present or absent), grassland type (*Baccharis*, *Lupinus*, open grasslands), and plot pair (1–12) nested within vegetation type as the grouping factors ($n = 24$ plots). We treated plot pair as a random factor and used Wilks' lambda values throughout. Response variables for the two MANOVAs were plant species richness and abundance for the following seven groups: exotic annual monocots, exotic annual dicots, exotic perennial dicots, exotic perennial monocots, native annual dicots, native perennial monocots, and native annual dicots. We performed a third MANOVA with the same model, with annual and perennial biomass as the two response variables. Prior to the analysis, we averaged data from all quadrats within each plot and log-transformed abundance and living biomass data to correct for heterogeneous variances. Data for whole-plot species richness met the assumptions of normality and equal variances and were left untransformed.

For all MANOVAs with significant elk treatment effects or any interaction terms that included elk treatment, we proceeded with "protected" analysis of variances (ANOVAs) on the individual response variables. As

discussed at length by Scheiner (2001), this approach is an effective method for dealing with potential correlations among multiple dependent variables and is used commonly with community data (e.g., Harrison et al. 2001; Alvarez & Cushman 2002; Cushman et al. 2004; Tierney & Cushman 2006). To determine whether elk influence the amount of dead biomass (thatch), we used an ANOVA with the above model and thatch biomass as the response variable. We log transformed thatch data to correct for heterogeneous variances.

To determine the effect of elk on the shrub cover, we analyzed data using a three-way ANOVA, with elk treatment (elk present or absent), grassland type (*Baccharis*, *Lupinus*, open grasslands), and plot pair (1–12) nested within vegetation type as the grouping factors ($n = 24$ plots). The response variable for this analysis was percentage of total shrub cover in each plot. We transformed proportion data to the arc-sine square root prior to analysis. To determine whether elk influenced the abundance of mature *Lupinus* shrubs, we used a two-way ANOVA with elk treatment (present or absent) and plot pair (1–4) as the grouping factors and mature *Lupinus* abundance as the response variable.

To determine whether the effects of elk herbivory on *Holcus* varied between *Baccharis* and shrub-free areas, we analyzed data on the biomass and abundance of this exotic grass using a three-way ANOVA, with elk treatment (present or absent), shrub (present or absent) and plot pair (1–4) as the grouping factors ($n = 16$) and plot (1–8) nested within pair. Prior to analysis, we averaged data from all quadrats within each plot and shrub level and data on *Holcus* biomass were log transformed to correct for heterogeneous variances. We analyzed data on juvenile abundance of *Lupinus* per plot with a one-way analysis of covariance (ANCOVA), with elk treatment (present or absent) as the grouping factor and abundance of mature shrubs per plot as the covariate.

Results

Plant Community Composition

The NMS analysis indicated that the composition of plant assemblages where elk were present differed from where they were excluded (Fig. 1). The MRBP analysis indicated significant differences between fenced and control plots ($A = 0.35$, $p = 0.0004$). In addition, a MANOVA indicated that tule elk significantly altered plant species richness of the seven plant groups considered collectively (Fig. 2; $F_{7,3} = 19.26$, $p = 0.017$). Subsequent protected ANOVAs showed that this result was due to significant differences in three of the seven plant groups and a trend in a fourth group. The presence of elk caused an 18% increase in richness of exotic annual monocots, a 47% increase in richness of native annual dicots, a 42% increase in richness

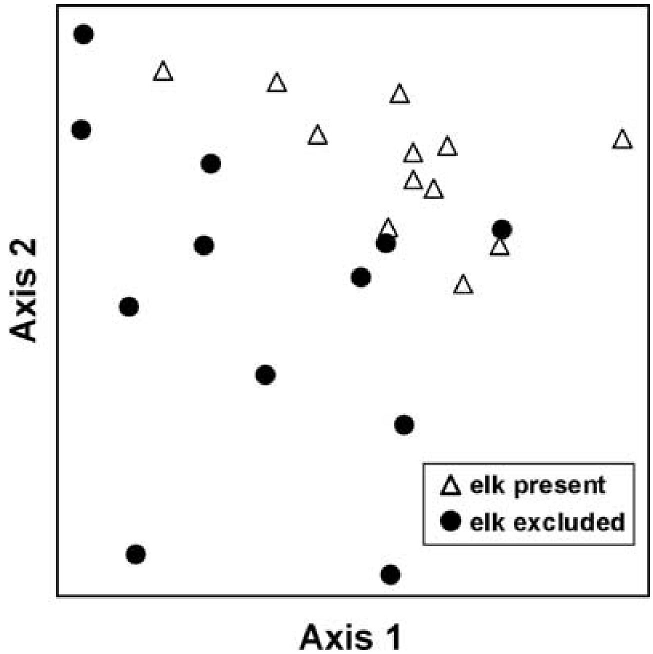

Figure 1. Results of nonparametric multidimensional scaling analyses of data on plant species abundance from plots where elk were present (open symbols) and where elk were excluded (closed symbols).

of native perennial monocots, and a 23% decrease in the species richness of native perennial dicots compared with exclosure plots (Fig. 2 & Table 1). In contrast to these four groups, elk had no significant effect on the richness of exotic annual dicots, exotic perennial monocots, or exotic perennial dicots (Fig. 2 & Table 1). Nevertheless, species richness varied significantly among grassland types for exotic annual dicots, native annual dicots, exotic perennial monocots, native perennial monocots, exotic perennial dicots, and native perennial dicots (Fig. 2 & Table 1). For all plant groups the response of species richness to elk manipulations was similar among grassland types, as indicated by the absence of significant treatment × vegetation type interaction terms ($p > 0.10$ in all cases).

A second MANOVA revealed that elk had a significant influence on the abundances of the seven plant groups considered collectively (Fig. 3; $F_{7,3} = 10.78$, $p = 0.038$). Protected ANOVAs on individual groups indicated that this result was due primarily to elk causing a 315% increase in the abundance of exotic annual monocots, a 78% increase in the abundance of exotic annual dicots, and a 245% increase in native annual dicots (Fig. 3 & Table 1). In contrast, elk had no effect on the abundance of exotic perennial monocots, native perennial monocots, exotic perennial dicots, or native perennial dicots (Fig. 3 & Table 1). Plant abundance varied significantly among grassland types for native annual dicots, exotic perennial monocots, and native perennial monocots (Fig. 3 & Table 1). For all plant groups, again the effects of elk were

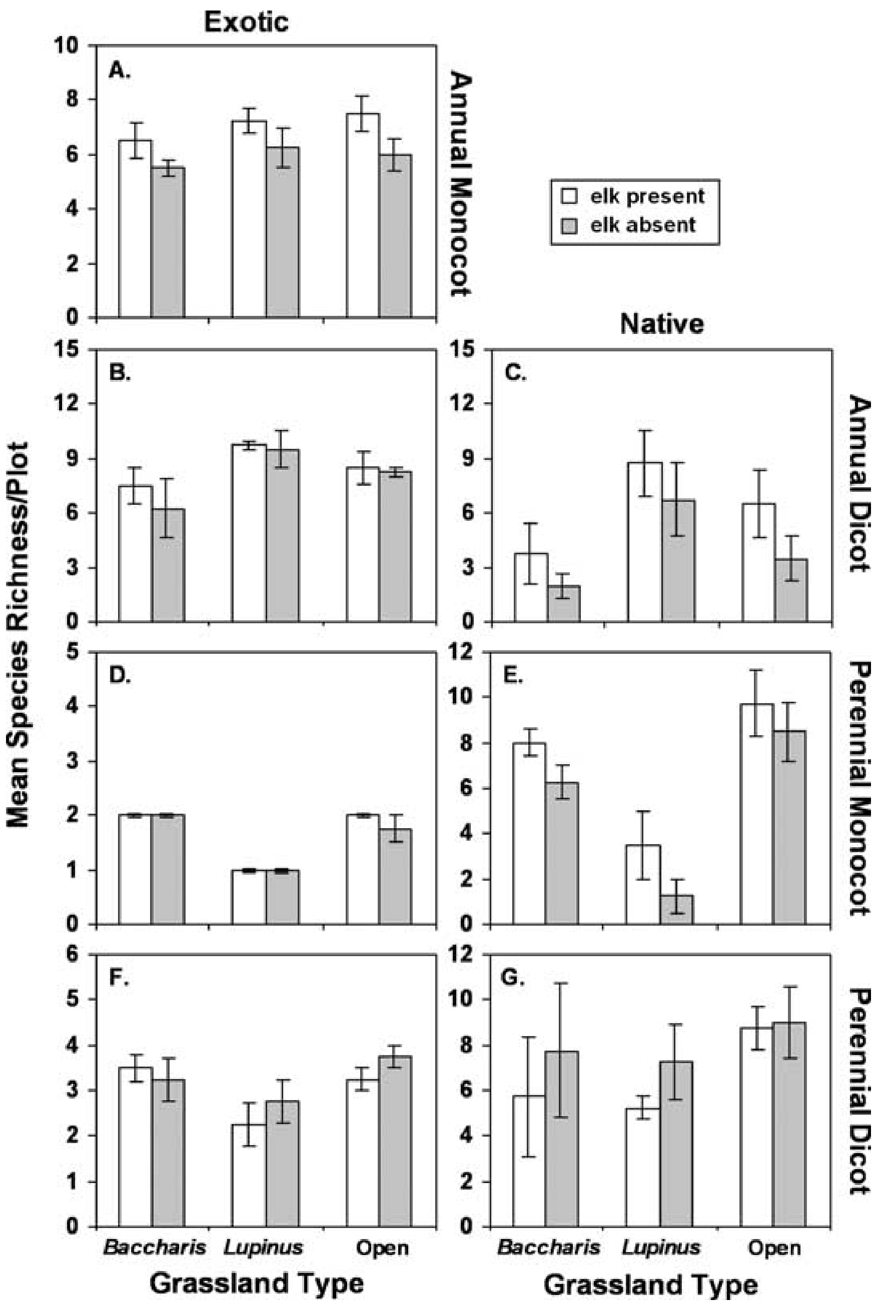

*Figure 2. Plant species richness (mean ± 1 SE) of seven herbaceous plant groups as a function of grassland type (*Baccharis, Lupinus, *and open) and the presence or absence of tule elk: (a) annual monocots, (b, c) annual dicots, (d, e) perennial monocots, and (f, g) perennial dicots.*

consistent across grassland types, as indicated by insignificant treatment × grassland type interaction terms ($p > 0.10$).

In a third multiway MANOVA tule elk significantly influenced the aboveground dry biomass of annual and perennial plant species considered collectively (Fig. 4; $F_{2,8} = 5.81$, $p = 0.028$). Subsequent protected ANOVAs revealed that elk increased annual biomass by 34% ($F_{1,9} = 7.13$, $p = 0.026$) but decreased perennial biomass by 50% ($F_{1,9} = 11.67$, $p = 0.008$) (Fig. 4). Annual and perennial biomass did not differ significantly among grassland types (Figs. 4a–b; $F_{2,9} = 1.94$, $p = 0.199$ and $F_{2,9} = 0.77$, $p = 0.491$, respectively). For both annuals and perennials, the effects of elk were consistent across grassland types, as indicated by the lack of significant treatment × grassland type interaction terms ($p > 0.10$). In addition, there was a nearly 200-fold increase in thatch where elk were excluded (Fig. 4c; $F_{1,7} = 47.65$, $p = 0.002$), and the influence of elk was greater in *Baccharis* plots than in open plots, as indicated by a significant treatment × grassland type interaction ($F_{1,6} = 19.42$, $p = 0.005$).

Cover and Density of Shrubs

Total shrub cover varied significantly among grassland types (Fig. 5a; $F_{2,6} = 24.36$, $p = 0.0002$). Cover was much greater in *Baccharis* grasslands than in *Lupinus* and open grasslands. In addition, elk caused a decrease in total

Table 1. Results from seven multiway analysis of variances for an exclosure experiment evaluating the effects of tule elk on the plant species richness and abundance for seven herbaceous functional groups across three different grassland types in northern California.*

Variable and source	*df*	Abundance F	Abundance p	Species richness F	Species richness p
Exotic annual monocot					
grassland type	2,9	1.83	0.215	3.00	0.100
elk treatment	1,9	35.35	0.0002	16.33	0.003
pair (grassland type)	9,9	2.45	0.099	4.44	0.018
G × ET	2,9	0.09	0.915	0.33	0.725
Exotic annual dicot					
grassland type	2,9	3.97	0.058	5.90	0.023
elk treatment	1,9	4.18	0.071	0.79	0.396
pair (grassland type)	9,9	0.44	0.878	1.91	0.175
G × ET	2,9	0.19	0.833	0.26	0.777
Native annual dicot					
grassland type	2,9	29.05	0.0001	3.12	0.094
elk treatment	1,9	5.20	0.049	5.47	0.044
pair (grassland type)	9,9	3.50	0.038	2.41	0.103
G × ET	2,9	1.47	0.281	0.13	0.878
Exotic perennial monocot					
grassland type	2,9	6.49	0.018	57.00	<0.0001
elk treatment	1,9	0.05	0.833	1.00	0.343
pair (grassland type)	9,9	2.98	0.060	1.00	0.500
G × ET	2,9	0.44	0.659	1.00	0.405
Native perennial monocot					
grassland type	2,9	45.55	<0.0001	40.97	<0.0001
elk treatment	1,9	0.57	0.469	7.83	0.021
pair (grassland type)	9,9	5.04	0.012	3.37	0.043
G × ET	2,9	1.18	0.352	0.21	0.812
Exotic perennial dicot					
grassland type	2,9	15.55	0.001	15.55	0.001
elk treatment	1,9	2.45	0.152	2.45	0.152
pair (grassland type)	9,9	6.82	0.004	6.82	0.004
G × ET	2,9	2.45	0.141	2.45	0.141
Native perennial dicot					
grassland type	2,9	4.76	0.039	4.76	0.039
elk treatment	1,9	3.69	0.087	3.69	0.087
pair (grassland type)	9,9	8.05	0.002	8.05	0.002
G × ET	2,9	0.63	0.557	0.63	0.557

*Abundance data were log transformed to correct for heterogeneous variances. Key: G, grassland type; ET, elk treatment.

shrub cover ($F_{1,9} = 3.78, p = 0.084$). Although this effect was greatest in the open grassland, we did not detect a significant treatment × grassland type interaction term ($F_{2,9} = 0.89$, $p = 0.445$). Elk significantly increased the abundance of juvenile *Lupinus arboreus* (Fig. 5b; $F_{1,4} = 10.55$, $p = 0.031$), which was not explained by differences in the number of mature *Lupinus* plants (mature × juvenile *Lupinus* interaction; $F_{1,4} = 0.27$, $p = 0.629$). Nevertheless, elk did not affect the abundance of mature *Lupinus* shrubs ($F_{1,3} = 0.0711, p = 0.807$).

Interactions among Elk, *Holcus*, and Shrubs

The influence of elk on the abundance of the exotic grass, *Holcus lanatus*, varied significantly with the local neighborhood inhabited by this invader. Specifically, we detected a significant interaction between herbivore treatment and local neighborhood (i.e., whether *Holcus* occurred underneath the canopy of the native shrub, *Baccharis pilularis*, or whether it occurred in shrub-free areas). Elk had a negative effect on the abundance of *Holcus* in the open grassland, but had no impact when the grass grew in association with *Baccharis* (Fig. 6a, $F_{1,6} = 6.15$, $p = 0.048$). There was a similar significant shrub × elk interaction term for aboveground dry biomass of *Holcus* (Fig. 6b, $F_{1,6} = 22.23$, $p = 0.003$).

Discussion

In our 5-year exclosure experiment we examined the effects of a reintroduced herbivore on the composition of a grassland community in coastal California. Annual and perennial plant groups responded to elk herbivory in distinct ways, but plant taxa within the same functional group generally responded similarly to herbivory, regardless of whether they were native or exotic. In particular,

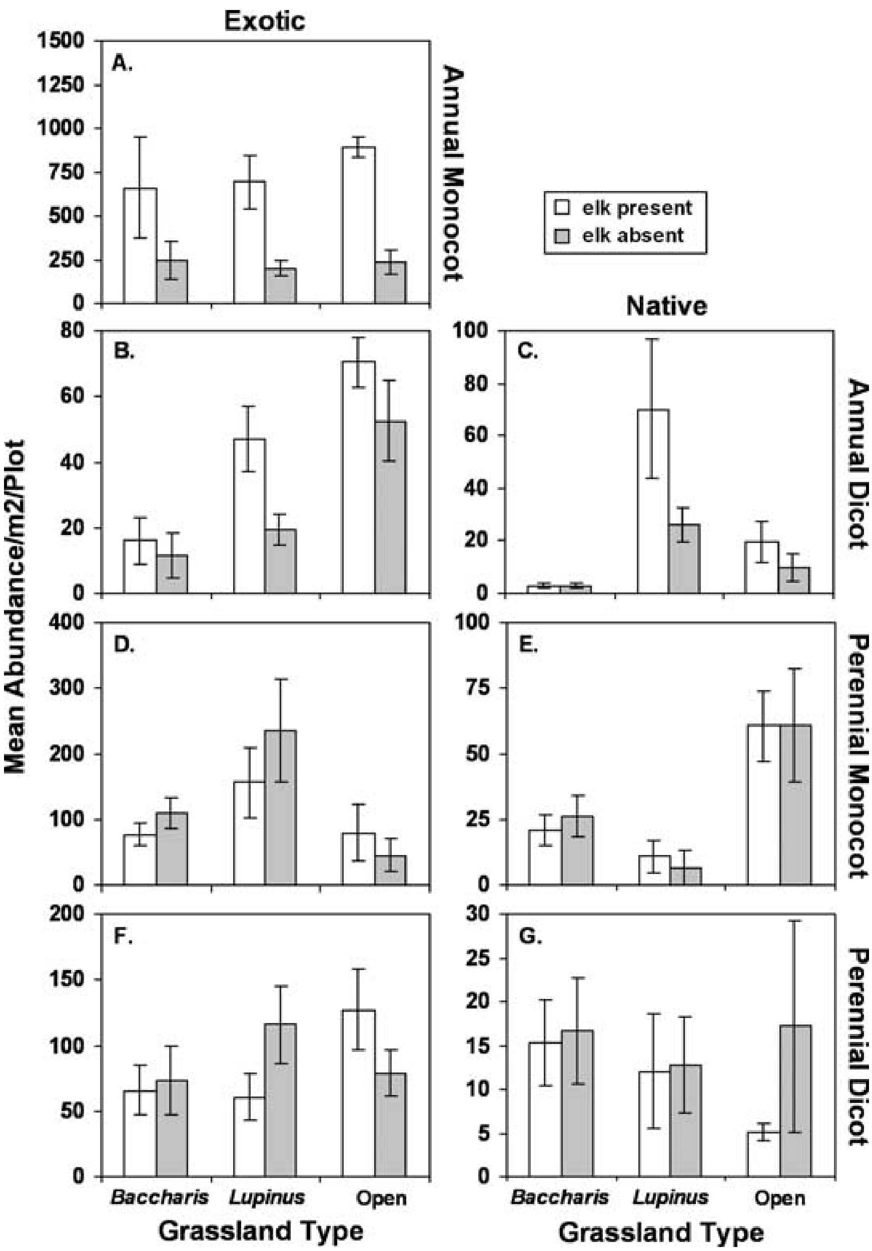

*Figure 3. Abundance (mean ± 1 SE) of seven herbaceous plant groups as a function of grassland type (*Baccharis, Lupinus, *and open) and the presence or absence of tule elk: (a) annual monocots, (b, c) annual dicots, (d, e) perennial monocots, and (f, g) perennial dicots.*

elk increased the abundance and biomass of both native and exotic annuals, decreased the biomass of native and exotic perennials, and had only minimal effects on perennial abundance (Figs. 3 & 4). Although elk herbivory enhanced native annual species, this came at the expense of increased abundance of exotic annuals.

Several hypotheses may explain the opposing effects of elk on annuals and perennials at our coastal grassland site. First, because elk reduce the accumulation of dead plant biomass (Fig. 4c), they may create favorable microsites for the germination and establishment of annuals by freeing up space in an otherwise closed grassland habitat. Support for this hypothesis comes from the many studies that show thatch can adversely influence the germination, survival, and/or growth of colonizing annuals (e.g., Carson & Peterson 1990; Facelli & Pickett 1991; Foster & Gross 1998).

Second, foraging elk may create favorable microsites for annuals in grasslands by trampling the dominant perennial vegetation with their hooves. Such disturbances favor annual taxa—especially exotics—that are adept at colonizing habitat openings (Hobbs & Huenneke 1992; Cushman et al. 2004). Perennials should be less responsive to both thatch reduction and trampling, given that members of this group (especially perennial grasses) exhibit lower recruitment and reduced colonization ability than annuals (Dyer et al. 1996; Hamilton et al. 1999; Seabloom et al. 2003; Tierney & Cushman 2006).

Third, elk may either feed preferentially on perennials or may simply have a greater effect on them because they

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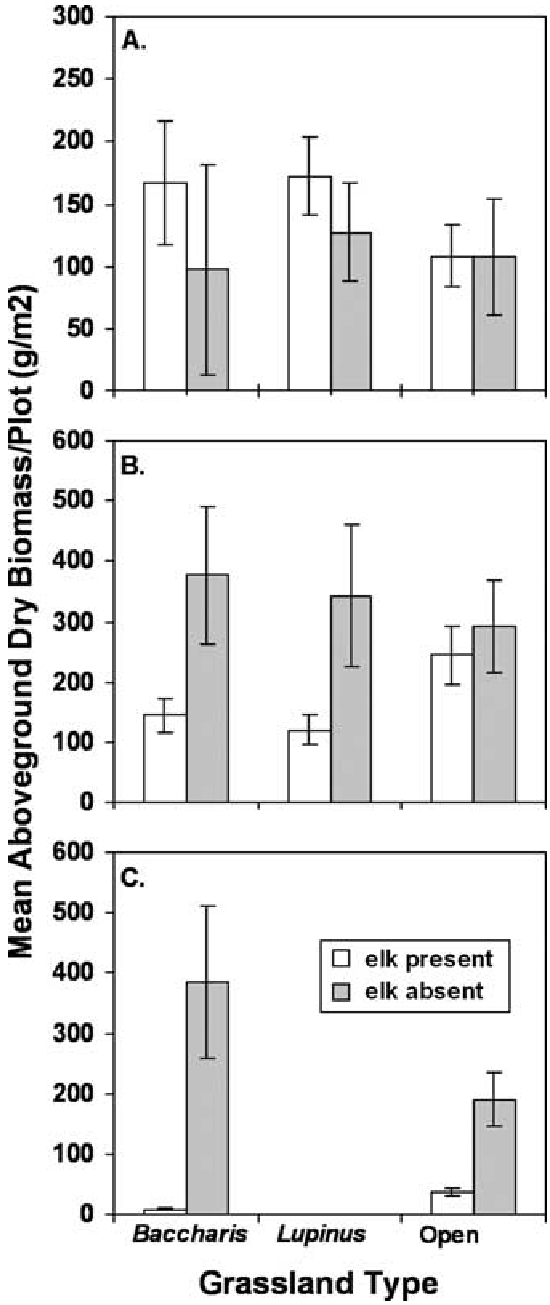

*Figure 4. Aboveground dry biomass (mean ± SE) of (a) living annuals, (b) living perennials, and (c) dead biomass (thatch) as a function of grassland type (*Baccharis, Lupinus, *and open) and the presence or absence of tule elk. The scale of (a) is half that of (b).*

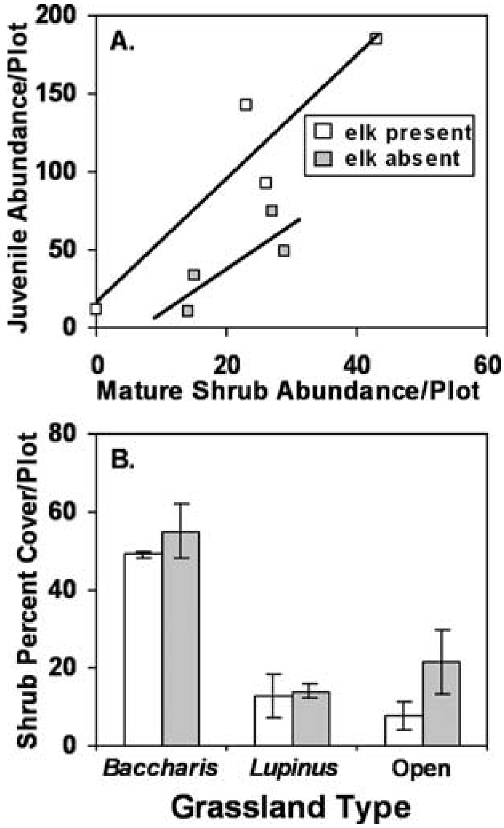

*Figure 5. (a) Percent cover of shrubs (mean ± 1 SE) as a function of grassland type (*Baccharis, Lupinus, *and open) and the presence or absence of tule elk and (b) the relationship between abundance of juvenile and established bush lupines (*Lupinus arboreus*) as a function of presence or absence of tule elk.*

are the dominant functional group in this system (Fig. 4). The decreased dominance of perennials should lead to increased water and nutrient availability that annuals can capitalize on. Results from several studies support this hypothesis, showing that mammalian herbivores can reduce dominant species and allow less competitive plant groups to flourish (e.g., McNaughton 1983; Collins 1987; Hartnett et al. 1996; Proulx & Mazumder 1998; Hayes & Holl 2003). For example, Collins (1987) demonstrated that cattle grazing increases the richness of tallgrass prairie annuals and that this increase is likely due to herbivores consuming a dominant grass species. We suspect that each of these factors—reduced accumulation of thatch, trampling of vegetation, differential impacts of herbivory, and altered competitive dynamics—were likely factors explaining the opposing responses of annuals and perennials to elk in our study.

From a management perspective, one of our most important findings is that elk herbivory greatly reduced the abundance and aboveground biomass of the highly invasive exotic perennial grass, *Holcus lanatus*. This species is a problematic invader in many mesic grasslands along the coast of California, and our work suggests that grazing may be an effective way to control its abundance and subsequent spread in open grasslands. Hayes and Holl (2003) also found that cattle grazing significantly reduced *Holcus* abundance at numerous sites in California.

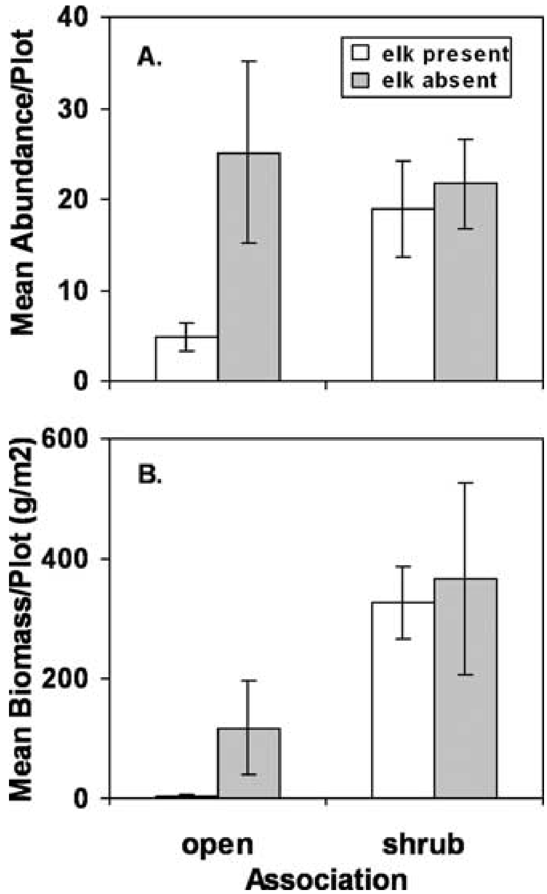

*Figure 6. (a) Abundance and (b) aboveground dry biomass (mean ± 1 SE) of velvet grass (*Holcus lanatus*) as a function of the presence of coyote bush shrubs (*Baccharis pilularis*) and the presence or absence of tule elk.*

A caveat to our results is that negative effects of elk on *Holcus* disappeared when the invader grew underneath the canopy of the native shrub, *Baccharis pilularis* (Figs. 6a-b). This type of associational resistance to herbivory is most likely due to elk having greater difficulty accessing *Holcus* when it grows beneath the canopies of *Baccharis* shrubs than when it occurs in the open. Others have considered the possibility that plants can avoid herbivory by associating with neighboring plants that make them less susceptible to herbivory (e.g., Atsatt & O'Dowd 1976; Huntly 1991; Hamback et al. 2000; Milchunas & Noy-Meir 2002). For example, Rebollo et al. (2002) demonstrated that the cactus, *Opuntia polyacantha*, provides protection from cattle grazing to many plant species that grow in association with it and that seed production is greater beneath cacti than in adjacent open areas. Our work builds on these results and illustrates the complexities that can arise in human-altered landscapes, where extirpated but now reintroduced native herbivores can control the dominance of problematic exotic plants, and that these invaders can in turn escape such control by associating with native shrubs.

Mesic grasslands in California are prone to shrub invasion (Hobbs & Mooney 1986; Callaway & Davis 1993), and our data show that elk decreased the cover of such taxa (Fig. 5b). These results are consistent with findings from other studies of elk in North America (Singer et al. 1998; Peinetti et al. 2001; Brookshire et al. 2002) and suggest that elk may play an important role in maintaining grasslands. The negative effect of elk on shrubs was stronger in the open grassland than in the *Baccharis*- and *Lupinus*-dominated grasslands. Over time we suspect that shrub cover will increase in the absence of elk but that such effects might be less pronounced in *Lupinus* and *Baccharis* grasslands because other environmental factors, such as water availability or variations in soil type, may be important regulators of shrub cover that override the effects of herbivores. An increase in shrub cover in any of the grassland types would result in a loss of plant richness in those areas because most herbaceous plant species on Tomales Point occur in open areas and not beneath shrubs (B.E.J., unpublished data).

Although elk had an overall negative effect on shrub cover, they had varying effects on *Lupinus arboreus* at different life stages (Fig. 5a). Elk increased the abundances of juvenile bush lupines, whereas they had no effect on the abundances of mature shrub. Elk may have promoted the initial establishment of lupines by disturbing the soil and/or by reducing the biomass of neighboring plant species (primarily grasses) that would otherwise compete with these juveniles for light, water, or soil nutrients. Once lupines reached maturity, they may have no longer competed with these neighboring taxa or other factors negated the initial increase in *Lupinus* juveniles caused by elk. For example, other herbivore species, such as invertebrates and mammals, reduce the growth and survival of juvenile bush lupines and may thus limit the abundance of mature plants (Maron 1998; Warner & Cushman 2002; McNeil & Cushman 2005).

Tule elk have been reintroduced in many parts of California that differ markedly in temperature, precipitation regimes, and community composition. This expansive distribution across a diversity of conditions makes it challenging to predict how broadly our results will apply to other locations. Although we suspect that elk will have profound effects on plant communities at all reintroduction sites, the magnitude and direction of these impacts may vary greatly. Hayes and Holl (2003) evaluated the effects of cattle grazing on multiple coastal grasslands in northern California and obtained results similar to ours for elk: grazing increased the species richness and cover of native annual forbs and decreased these parameters for native perennial forbs. Hayes and Holl hypothesized that cattle promote annuals by reducing the dominance of perennial grasses and dead biomass and thereby free up resources. Results from this study combined with our

own suggest that domesticated and native grazers may have similar impacts on coastal grasslands and that our results are applicable to other mesic grasslands along the Pacific coast.

In more arid grasslands large mammalian herbivory may exert radically different influences on grasslands (Olff & Ritchie 1998; Kimball & Schiffman 2003). For example, accumulated biomass may have the opposite effect in xeric climates of what we found in our mesic system because it may provide protection to seedlings from intense sunlight and heat (Foster & Gross 1998). Soil conditions may also influence how plants respond to mammalian herbivory, as shown by Harrison et al. (2003), who demonstrated that cattle grazing on grasslands in northern California with serpentine soils increases the richness of native species and grazing on nonserpentine soils has the opposite effect. The difficulty in predicting how vegetation with distinct characteristics will respond to the reintroduction of herbivores underscores the importance of well-designed studies that assess the community-level consequences of these mammals. We strongly urge land managers to establish clear goals about what kind of system they wish to maintain prior to initiating reintroduction programs and to implement rigorous monitoring efforts to determine whether these goals are met.

The management implications of our results are complex because tule elk had an overall positive effect on native species composition, but this came at the cost of increasing the richness and abundance of exotic taxa in the community. Elk also appeared to play a critical role in maintaining open grasslands and preventing certain areas from being converted to less diverse, shrub-dominated systems. These results demonstrate that a reintroduced herbivore species can have profound effects on ecosystems and that land managers need to monitor not only the status of the reintroduced herbivore population, but also the diverse impacts that reintroduced herbivores have on different components of the community.

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005246

An Approach for Park Managers to Identify Areas of Recreation-Wildlife Conflict

by

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B.A. (Sonoma State University) 2007

A professional report submitted in partial satisfaction of the requirements for the

degree of Master of Landscape Architecture

in the Graduate Division of the

University of California, Berkeley

Committee in charge:

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Ben Becker, Ph.D.

Spring 2009

The professional report of Christopher Michael Moi is approved:

Chair ____ Date __________

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____ Date __________

LIST OF FIGURES

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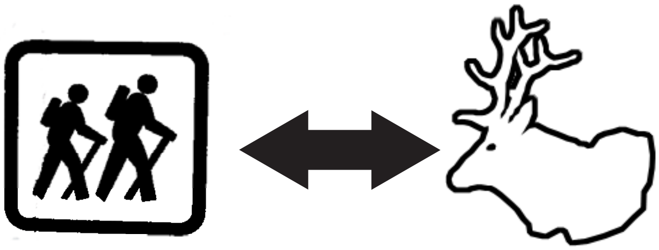
INTRODUCTION

"..to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (National Park Service Organic Act)



When wildlife persistence is jeopardized by human recreation, the balance of recreation can be difficult to achieve. The National Park Service is mandated by its enabling legislation to conserve the "wild life" and natural resources found within its parks while at the same time providing opportunities for people to use and enjoy those resources.

Figure 1: A Male Tule Elk at Tomales Point

Source: B.Katzung, 2004

Park managers have an especially difficult wildlife management situation at Tomales Point (the Point) in the Point Reyes National Seashore because:

- The tule elk (*Cervus elaphus nannodes*) are in an enclosed reserve
- The Point has a high visitation rate on a per acre, per year basis
- The tule elk seem to use two areas in particular for breeding and calving
- The Point is part of the Phillip Burton Wilderness which adds additional management requirements

The situation at the Point prompted wildlife managers at Point Reyes to initiate a study in 2002 to investigate elk behavioral response to different recreational groups. The study focused on the two areas identified as core breeding and calving areas - White Gulch and Avalis Beach (Howell et al. 2002) (see figure 2). The key findings of that study were that the elk were less likely to remain in the study area during an observation session and that elk were more likely to exhibit an active behavior such as running, walking away or standing when hikers were present (Becker and Moi 2008).

These findings have significant management implications considering that elk breeding and calving activity are primarily restricted to two areas on the Point. Any disturbance during the elk breeding and calving season will have a pronounced impact on the elk, forcing them to move out of their preferred habitat.

From the observational study it is known that there is an interaction between hikers and tule elk occurring at Tomales Point although it is unknown where the interaction is happening. This interaction is potentially harmful but the known concentrations of hikers and the concentrations of elk sightings are needed so that areas of recreational conflict with wildlife can be elucidated. It is essential for park managers

to know the areas of highest interaction so that they can mitigate impacts through the placement of signage that encourage low impact visitor behavior.

From previous study (Howell et al. 2002) it is known where the preferred habitat of the tule elk is on Tomales Point although it is not known where people are seeing the elk and going off-trail to disturb them.

It is unknown what will happen to the elk population at Tomales Point if recreation impacts are left unchecked. At the very least, the tule elk exert unnecessary energy by avoiding people who hike off-trail. In addition, elk may become habituated to constant contact with humans, which would conflict with the National Park Service mandate to preserve the wildlife in its natural state.

This report attempts to identify a process by which park managers can identify areas of recreational conflict with wildlife by using a survey instrument and a Geographic Information Systems (GIS) analysis to:

- investigate the recreationist-elk interaction potential at White Gulch and Avalis Beach
- identify concentrations of elk sightings by people
- identify where hikers are going on Tomales Point - both on and off the main trail
- recommend where mitigation should occur

This process offers a relatively quick, inexpensive way to use social science data collected through visitor surveys to inform resource management. Using park visitors as “eyes on the ground” in the absence of funding for wildlife or human tracking may be an effective way for park managers to get quick information about park visitors’ perception of impacts and where visitor impacts are spatially located, so that management actions can be tailored accordingly. Knowing where park visitors are within a park is key to

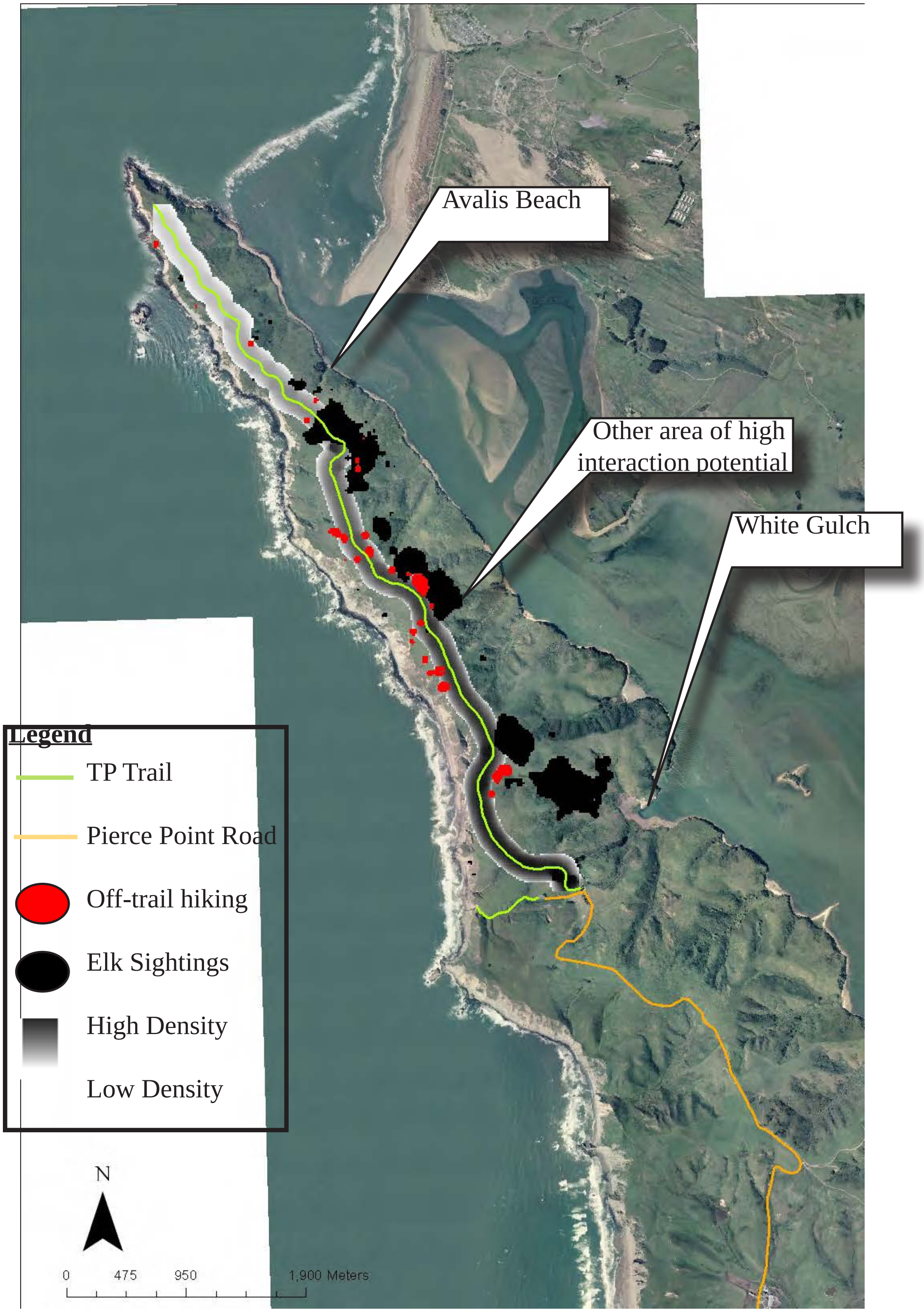
reducing conflict between recreationists and wildlife. For example, park managers may know which areas a species inhabits, but without knowing which areas are used by people there is no way to know if that species is at risk from human disturbance.

- Chapter 1 of this report is composed of a site analysis conducted to better understand the existing conditions at Tomales Point.
- Chapter 2 provides a background review of literature supporting the idea that human recreation can and does impact the tule elk at Tomales Point.
- Chapter 3 briefly discusses the brief natural, tule elk and human history at Tomales Point on the Point Reyes peninsula.
- Chapter 4 discusses in detail the method used for this report - the survey instrument used, the GIS analysis conducted and why those particular methods were chosen.
- Chapter 5 will discuss the results of the analysis.
- Chapter 6 will discuss management recommendations based upon the analysis and ways this report could be improved upon or added to in the future.

The method used in this research showed the areas of concentrations of elk and people are on Tomales Point. Potential conflict areas are identified, as well as areas where signage should be placed to persuade people to remain on the trail and encourage people to engage in low impact behavior.

It was found through the analysis that there are concentrations of elk sightings near both White Gulch and Avalis Beach (see figure 2). At White Gulch there is a higher density of people which intuitively makes sense because of its short distance to the trailhead. However, at Avalis Beach there is a high concentration of elk sightings but less people meaning more elk seen per person hiking which indicates high interaction

Figure 2: Composite Map Showing Areas of Highest Potential Interaction



*Concentrations of off-trail hiking locations (red) and elk sightings (black). Concentrations of visitors on-trail shown from highest density (black) to lowest (white).

potential.

Additionally, through this analysis, another area of high interaction potential was discovered between White Gulch and Avalis Beach (see figure 2). While this area has not been identified as core habitat, frequent elk sightings by hikers suggests that tule elk often use this area. Tule elk herds may have started using this area as well for breeding and calving; this area should be researched further to determine if this is in fact true.

To mitigate this interaction, signage should be placed at the trailhead, at White Gulch and at Avalis Beach to persuade park visitors to not approach elk or to go off-trail in these areas. Additionally, a buoy or some other object could be placed at the trailhead illustrating how far people should be from tule elk at all times (see figure 19). Furthermore, a more accurate measure of how many people use Tomales Point per day would give managers a better idea of how to adapt mitigation to reflect varying use levels.

Point Reyes has a rich tradition of involving science and university researchers in the planning and management of the park. At Tomales Point there have been many research projects initiated as partnerships between the National Park Service and Master's and Ph.D. students. The previous studies have focused on assessing tule elk herd size and composition, disease, impact of tule elk management on endangered species and evaluating the vegetation of the tule elk range. However, none of the studies have investigated the interaction between park visitors and tule elk on Tomales Point and this report attempts to fill that gap.

CHAPTER 1: SITE ANALYSIS

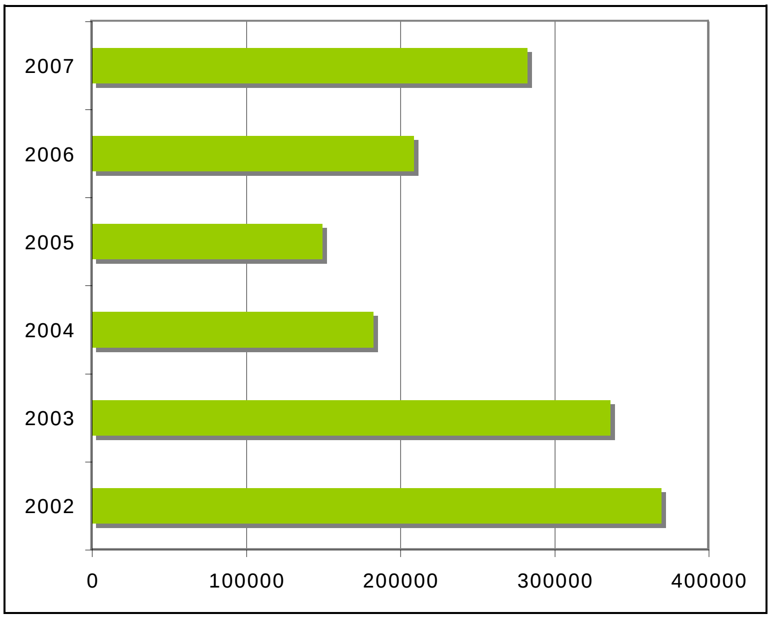
Figure 3: Point Reyes peninsula with Tomales Point shown in orange box

Point Reyes National Seashore is a 71,000-acre park located about 30 miles north of San Francisco, California and within driving distance of the nine-county San Francisco Bay Area and approximately 7,000,000 people (Bay Area Census website 2007). The park has 32,000 acres of designated wilderness, which includes Tomales Point and the 2,300-acre tule elk (*Cervus elaphus nannodes*) reserve. The entire park had 2,232,082 visitors in 2007, and nearly 300,000 of them visited Tomales Point and the tule elk reserve (NPS public use website) (see figure 4). The park has had numerous public comments at public meetings and elsewhere that the tule elk are a great attraction drawing people from all over to Tomales Point (Seashore 1998).

In 1976, about 50 percent of Point Reyes National Seashore was declared wilderness by Congress, thus furthering the preservation mission of park (NPS 1980).

Within wilderness areas, motorized vehicles and commercial activities are prohibited in an effort to preserve areas that have remained "untrammeled" by man. Wilderness areas are to remain undeveloped and only minimalist signage and other activities are allowed within areas of designated wilderness (Seashore 1998).

Figure 4:Tomales Point Visitor Statistics*



*Car count data was subtracted at Sir Francis Drake and Pierce Point Road from Tomales Bay State Park car count data (Source: NPS Public Use Website; Tomales Bay State Park Public Use Records)

EXISTING CONDITIONS

Tomales Point is located at the northernmost point of the Point Reyes National Seashore. The tule elk reserve at the Point is approximately 1,052 hectares (2,600 acres) in size (Howell et al. 2002). The tule elk range extends from the northernmost tip of the Point Reyes peninsula 5 miles southward with the southern boundary marked by a three-mile-long, 8-foot-high fence that separates the herd from surrounding active cattle ranches and is bordered on the west by the Pacific Ocean and the east by Tomales Bay (Gogan 1986; Seashore 1998; Howell et al. 2002).

Pierce Point Road is the only access road allowing entrance to the reserve by car. Since the tule elk reserve is part of the Phillip Burton Wilderness Area, there are no bicycles or motorized vehicles allowed on the trail. The Tomales Point trail is a 4.7 mile out-and-back trail. The trailhead parking lot is adjacent to the historic Pierce Point dairy. Dairy buildings remain and are part of an interpretive trail with signage that discusses the productive history of the ranches on Tomales Point.

Tomales Point is visited by hundreds of thousands of people every year (see figure 4). Visitors can access the Point by driving to the trailhead on Pierce Point Road and hiking on the Tomales Point trail, by hiking up onto the Point from McClures Beach or by boat at numerous beaches along the east of the Tomales Point peninsula.

Avalis Beach is one of the beaches that can be used to access Tomales Point. Avalis Beach was also identified as core breeding and calving habitat by Howell et al. (2002). The area is frequented by boaters and hikers. There are currently two signs that are in very poor condition that attempt to encourage people to use other beaches to hike onto Tomales Point because Avalis Beach is tule elk habitat (see figure 7).

White Gulch was also identified by Howell et al. (2002) as breeding and calving habitat for the tule elk. Currently there are no signs informing hikers that White Gulch is important elk habitat. There is an unofficial spur trail that has been created at White Gulch that was probably created by both hikers and elk. When hiking on the main trail, it could be difficult to discern that the spur trail is not an official trail. White Gulch is mostly used by hikers, although boaters can access Tomales Point through the little bay inlet (see figure 8).

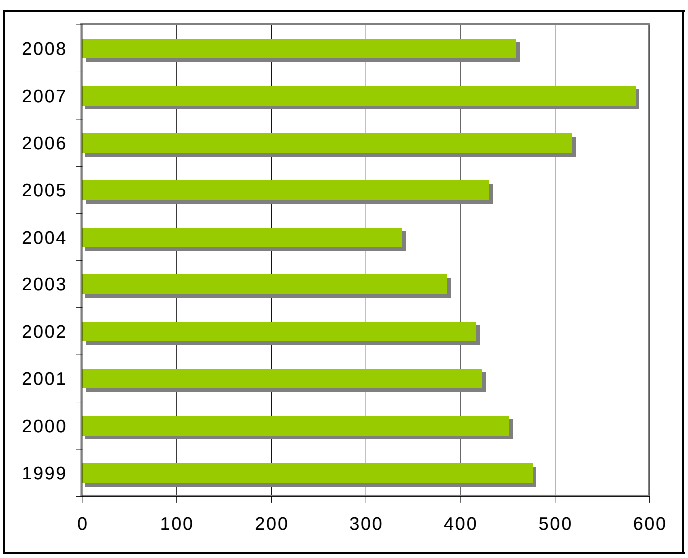
The Tomales Point trailhead does not have any signs with information about the

tule elk with the exception of an 8 1/2 inch by 11 inch laminated sheet of paper discussing the tule calving season (see figure 28). The remaining existing signs discuss the historic Pierce Point dairy, general information about Tomales Point and Tomales Point trail and mountain lion safety.

In addition, there is an "exhibits" area located off Pierce Point Road before one arrives at the trailhead (see figure 10). This is the only place where there is a sign that mentions the tule elk (see figure 6). While this area is a good place for a view of the historic dairy, Tomales Bay and Tomales Point, it seems to be used infrequently by visitors and the tule elk sign would be better utilized down by the trailhead parking lot.

The tule elk population at Tomales Point at present is approximately 459 individuals. The present population is markedly lower than in years past (see figure 5 below). All age groups and sex classes have declined to the lowest minimum population estimate since 2005 (unpublished Point Reyes annual elk census).

Figure 5: Tomales Point Tule Elk Population Estimates



Source: Unpublished Annual Tule Elk Census (NPS)

Figure 6: Tule Elk Sign at the Exhibits Area*

*This sign could be moved down to the trailhead parking lot

Figure 7: Current Sign at Avalis Beach Warning Visitors of Area's Importance

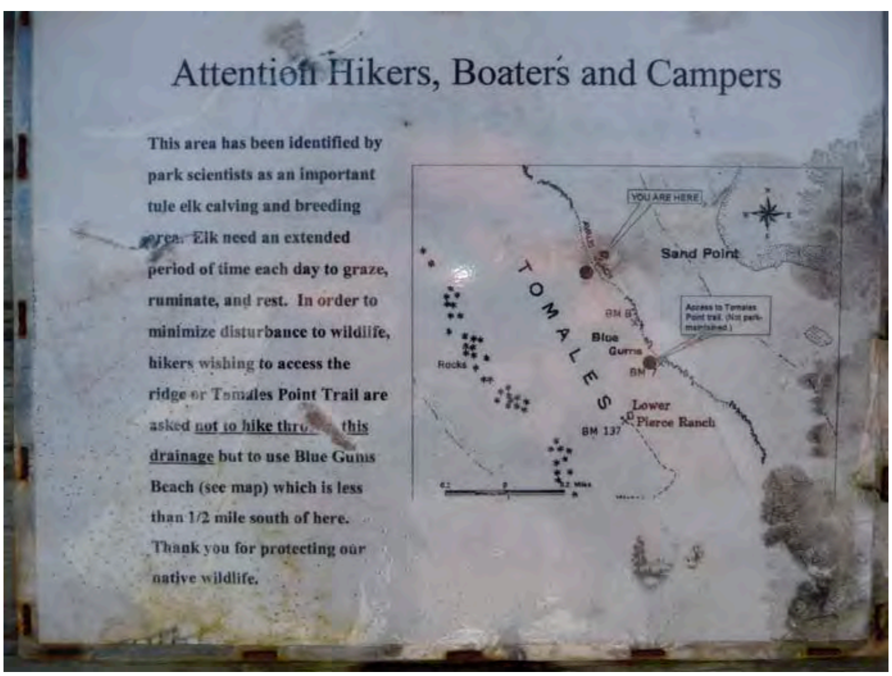


Figure 8: Existing Conditions at Tomales Point

Figure 9: Trailhead Existing Conditions

Figure 10: "Exhibits" Area

Currently, the Tomales Point trailhead is underutilized as a place to engage and educate the public about recreational impacts and the interesting history of the tule elk. A few small improvements could be made to illustrate how humans can enjoy a resource such as the tule elk without disturbing or harming them.

CHAPTER 2: BACKGROUND

"A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Aldo Leopold, A Sand County Almanac.

Visitors to Tomales Point are having direct, observable impacts on tule elk behavior when they move off the main trail to view or photograph the elk or when they approach elk when off-trail. While it is not yet clear if these activities are causing the population or reproductive success of Tule elk to decline, there may still be long term effects resulting from this disturbance.

When studies fail to find significant influences of recreational disturbance on wildlife, it may not be because the disturbance is unimportant, but rather the effect may be subtle and not easily detected (Knight and Cole 1995). As explained by Borkowski and others (2006) in their study, over-snow vehicles elicited little observable response. However, they commented how recreational activities can have physiological effects on wildlife that are not readily observable such as increased heart rate, blood pressure and respiration as well as release of adrenaline. The release of adrenaline causes the diversion of energy from physiological processes not needed for immediate survival.

Borkowski and others (2006) went on to say that the Yellowstone elk population remained relatively constant throughout the study and that any effects of disturbance seemed to be alleviated at the population level. They also discussed how park constituency reactions to the situation at Yellowstone could be grouped into two general extremes:

1. Elk are not being harmed because the population is not going down;
2. Human activities that induce any stress in wildlife should be curtailed

Studies have shown that scientific findings rarely cause people to alter their beliefs, and interpretation of response and behavioral data will vary by individual personal values (Borkowski et al. 2006). However, Marion and Reid (2007) in their analysis of low impact visitor education research, reported that people were more likely to be persuaded to alter their behavior for ecological rather than social reasons.

That said, it is hypothesized that if visitors to Tomales Point were aware that their activities could have a negative effect on the tule elk there would be a reduction in recreational impact. Littlefair and Buckley (2008) showed that educating visitors on how to minimize impacts to wildlife reduced visitor impact. In addition, Taylor and Knight (2003) postulated that recreationist perceptions regarding their effects on wildlife may influence their behavior on public lands and knowledge of visitor perceptions can help managers encourage positive visitor behavior between wildlife and them.

Therefore, visitors were surveyed at Tomales Point to investigate their perceptions regarding recreational effects on wildlife, specifically the tule elk, and to locate areas of high human-elk interaction. As with Taylor and Knight (2003), it was predicted that most people would not think recreation has an impact on the wildlife at Tomales Point (however, most people did agree recreation can negatively effect wildlife, see chapter 5). People were also asked what motivated them to hike at Tomales Point to get an idea what might be driving people's behavior when recreating there.

The concept of motivation is important in explaining the basis of the conflict between recreation and conservation (Knight and Cole 1995). Motivations have

expectancies and norms associated with them. People recreate with the expectation of some reward, fulfillment or other specific outcome. In addition, prior to arrival at a park, people have preconceived notions or norms of what type of behavior is appropriate and acceptable in different situations (Kuss and Graefe 1990; Knight and Cole 1995).

Recreational activities are known to have undesirable consequences for wildlife. Activities such as hiking, biking or horseback riding were once thought of as benign, because their related impacts were spread over large areas (Knight and Cole 1995; Taylor and Knight 2003). Recently, recreational activities have gotten more attention for their potential to disturb wildlife (Knight and Cole 1995). As the human population increases, recreationists will increase. Recreational activities expected to increase most rapidly are nonconsumptive activities such as day hiking and bicycling (Knight and Cole 1995).

Nonconsumptive recreational activities can have direct or indirect effects on wildlife and can affect wildlife at the individual, species, community, or population level. Examples of direct effects are intentional harassment of wildlife by people or unintentional disturbance of wildlife by wildlife photographers that cause animals to alter their behavior. Indirect effects of recreational activities are the degradation of the landscape through erosion or refuse or the simplification of vegetation communities (Knight and Cole 1995).

Wildlife managers are challenged to deal with a wide variety of wildlife responses to human activity. Three general responses of wildlife to disturbance are avoidance, attraction and habituation (Knight and Cole 1995). Wildlife will exhibit avoidance responses when human activity is associated with negative consequences, attraction when associated with positive outcomes, and habituation when the encounter is considered

neutral (Knight and Cole 1995). In addition, as mentioned before, wildlife managers are challenged by a broad mandate to protect and conserve park wildlife and resources, allow people to access and enjoy those resources and protect people from potential natural hazards (Knight and Cole 1995).

Numerous studies have shown that pedestrians have the greatest potential to disturb wildlife (Schultz and Bailey 1978; Boyle and Samson 1985; Taylor and Knight 2003). In Schultz and Bailey (1978) elk took flight at a greater distance when approached on foot. In his recent review of recreational disturbance on ungulates, Stankowich (2008) found that, in general, humans on foot are the most disturbing to ungulates, more than humans on horseback and bicycling, although humans on bikes have the opportunity to disturb more wildlife per unit time than people on foot (Taylor and Knight 2003).

Additionally, nature viewing and wildlife photography have great potential to disturb wildlife because people partaking in these activities actively seek out animals and are more likely to approach them, and the disturbance is likely to be more frequent and longer in duration (Boyle and Samson 1985; Knight and Cole 1995). In addition, backpacking, hiking and horseback riding can effect wildlife by displacing individuals (Knight and Cole 1995). Furthermore, wildlife may avoid areas with high human activity, which may reduce the carrying capacity of public lands (Taylor and Knight 2003).

If the disturbance is heavy but only in a limited area animals may exhibit “adaptive redistribution” which may cause them to move from high quality habitat to more marginal habitat (Knight and Cole 1995). Dyke and Klein (1996) showed that elk made use of habitat and terrain to reduce visual contact with disturbance. The population

slightly reduced the size of its total range and increased the use of core habitat areas and reduced the distance kept between individuals.

As mentioned in the introduction, the tule elk at Tomales Point are particularly vulnerable to recreational disturbance because they are in an enclosed reserve. Adding to their vulnerability is the fact that they have restricted most of their breeding and calving activity to two areas within the enclosed reserve. If elk are disturbed during these critical periods in their life cycle by recreationists there is great potential for the population at Tomales Point to be jeopardized.

CHAPTER 3: HISTORY

POINT REYES NATURAL HISTORY

Point Reyes Climate

The temperate Mediterranean climate of California is typified by winter rain and summer drought. The same climate can be found at Point Reyes. While some people would argue that there are only two seasons seen in California, the rainy season and the dry season, the coastal Miwok believed there were 13 seasons (Evans 2008). Despite the clear differences between summer and winter in California and Point Reyes, the average monthly temperature remains relatively constant year-round. The temperature rarely exceeds 90 degrees Fahrenheit in the summer or drops below 40 degrees Fahrenheit in the winter (Seashore 1998). The average temperature for midsummer is 55 degrees Fahrenheit and the average temperature for midwinter is 50 degrees Fahrenheit (Evans 2008). The air on the peninsula is full of moisture, which insulates the land from seasonal temperature extremes and provides water to keep the tule elk range productive. The constant temperature makes the Point Reyes peninsula one of the most hospitable climates to live in the world (Evans 2008).

Total rainfall for the peninsula averages about 25 inches per year with some annual variation. Drought does occur however, where rainfall may be half of what it normally is (Seashore 1998). Gogan (1986) theorized that precipitation for Tomales Point is likely lower than for Inverness Ridge although Tomales Point is covered with advective fogs from May to August.

While, generally speaking, the climate of Point Reyes is constant, there are wide variations in microclimates throughout the peninsula. For example, there is twice as

much rainfall in Bear Valley as at the Point Reyes lighthouse (Evans 2008). Both of these sites vary widely in vegetation as well, with Bear Valley having lush forests associated with Inverness Ridge and the lighthouse having coastal scrub and grassland (Evans 2008).

Furthermore, the temperatures in east or south facing canyons can have temperatures that may be as much as 12 to 14 degrees warmer than the coastal ocean bluffs (Evans 2008). Moreover, there can be extreme variation between vegetation within the same canyon on opposite slopes and is most obvious in east-west facing canyons with full southern exposure on one side (Evans 2008). These slopes are typified by having drought tolerant shrubs and trees with small leaves to reduce transpiration and water loss. There are multiple factors that contribute to microclimactic variation such as exposure to prevailing winds, exposure to summer fog, distance to the ocean or bay and human uses (Evans 2008).

The western bluffs of the elk range on Tomales Point have microclimactic variation as well. The ocean bluffs in the west are often 10 to 15 degrees Fahrenheit cooler than the east-west running canyons exposed to full sun (Seashore 1998). In addition, winter storms have been known to deposit large amounts of rain along the coast but only light rain inland a few miles away (Seashore 1998).

Point Reyes Geology

The geologic origins of the Point Reyes peninsula are not well known (Evans 2008). Evans (2008) discussed one potential scenario –

“Perhaps it began in some shallow lagoon along the Mexican coast, where fine

sediments of sand, clay, and lime were deposited in a pre-Cretaceous period more than 145 million years ago, or even as early as the great Paleozoic (at least 225 million years ago), before the ascendancy of birds and mammals."

What is known is that the geology of the peninsula is constantly changing. Today, Point Reyes sits at the eastern edge of the Pacific Plate and is sliding past the North American continent in a northwesterly direction. The peninsula's bedrock is changing due to the Pacific Plate subducting under the North American Plate (Evans 2008).

Evans (2008) went on to explain the geology of the peninsula as being separated generally into three different geologic regions: the large granitic body of Inverness Ridge, the large granitic outcrop of Point Reyes headlands now covered with conglomerates (small pieces of rock cemented together), and the area in between the two with "some structural elements underlain by granite".

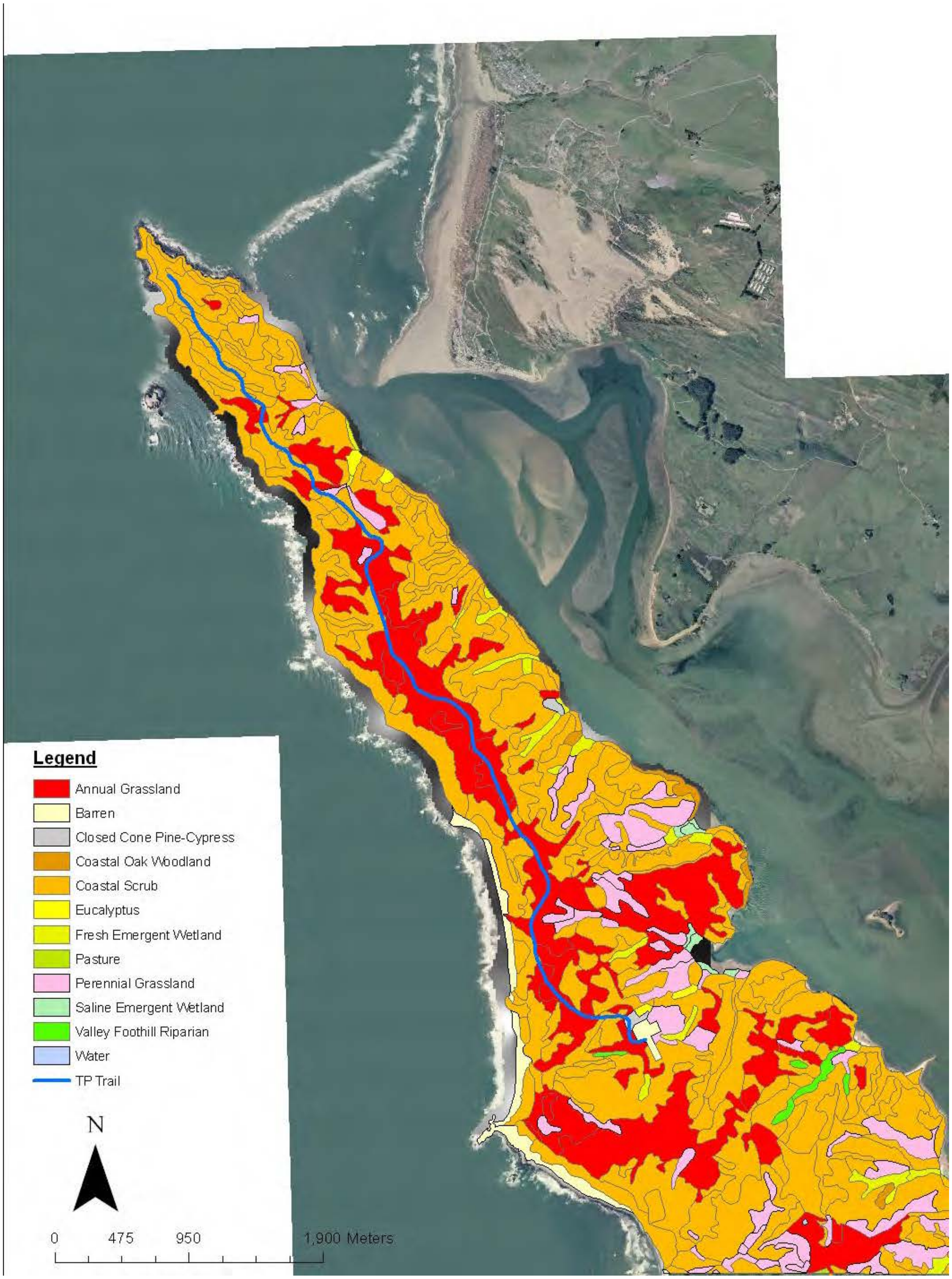
In Gogan (1986), quoting from Galloway (1977) – "The plutonic rock underlying Tomales Point, '… ranges in composition from quartz diorite through granodiorite to adameilite.'" Gogan (1986) went on to say that granitic outcrops occur widely at Tomales Point and granodiorite "occurs as wave-cut bluffs up to 45 m[eters] above sea level."

Tomales Point is mostly covered by a single soil type classified as the Kehoe Variant of the Sheridan Baywood Association (Gogan 1986).

Point Reyes Vegetation

The vegetation of Point Reyes peninsula can be separated into seven different

Figure 11: Tomales Point Vegetation Map Using California Wildlife Habitat Relationship (CWHR) Classification System



communities – Douglas-fir and mixed evergreen forest, mixed evergreen hardwood forest, Bishop pine forest, coastal scrub, grassland, beach and dune and tidal marsh (see figure 11). Since the arrival of Europeans the grasslands have been converted from a diverse community of annual bunchgrasses, forbs, and small shrubbery to one dominated by nonnative annual grasses. In addition, severe grazing on the peninsula has artificially selected perennial grasses over annual grasses and limited the range of the coastal scrub (Evans 2008), although Native American burning practices likely modified vegetation communities as well (Gogan 1986).

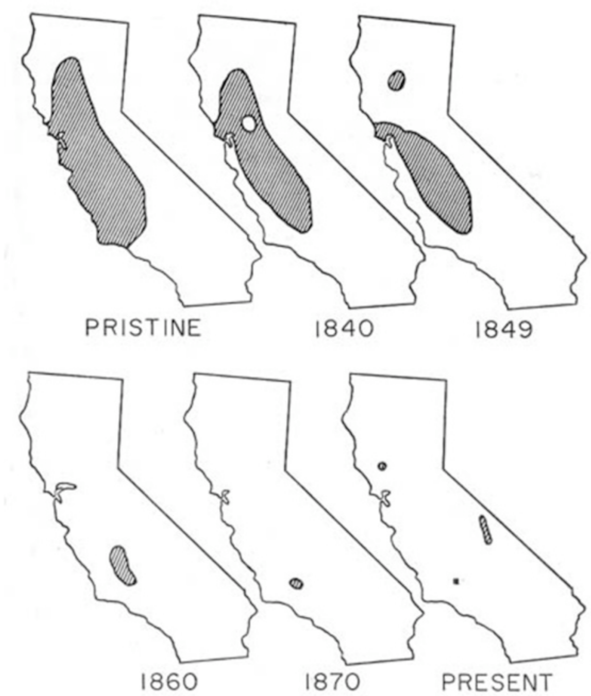
According to Howell and others (2002), the tule elk range on Tomales Point can be classified into four vegetation communities: open grassland, lupine grassland, coyote bush grassland and dense scrub. In addition to the tule elk, the tule elk range is home to three federally listed plant species – the Point Reyes blennosperma, the North Coast bird's beak and the San Francisco owl's clover. Additionally, the range is home to the federally endangered Myrtle's Silverspot butterfly (Howell et. al 2002).

TULE ELK HISTORY

> *"Point Reyes was drenched with fog, but as the day wore on it lifted; and ahead of them they saw a herd of elk on a rise of land – 'not less than 400 head of superb fat animals.'* (Mason, 1970)

There were once as many as 500,000 tule elk that roamed the grasslands of the San Joaquin Valley from the Shasta Valley south to Bakersfield, east to the Sierra foothills and west to the coast (see figure 12).

Figure 12: Historical Tule Elk Distribution in California



Source: (McCullough 1969)

The gold rush in the mid 1800s and the associated population and development boom, fur traders, tallow industry and market hunting for restaurants in San Francisco nearly drove the Tule elk population to extinction ((McCullough 1969; McCullough 1996). By 1873, it is estimated that there were as few as 28 tule elk remaining in California (McCullough 1969; McCullough 1996).

The largest remnant population was found on a private ranch near Bakersfield owned by Henry Miller, a wealthy landowner (McCullough 1969; McCullough 1996). Henry Miller saw the importance of conserving the remaining tule elk and along with other concerned individuals fought to establish the first tule elk reserve in Bakersfield in 1932 (McCullough 1969; McCullough 1996).

Tule Elk History at Point Reyes

The earliest accounts of tule elk presence at Point Reyes are from the Spanish crew of the San Augustin in 1595 (Gogan 1986).

The Olema Valley on the Point Reyes peninsula used to contain greater than 1,000 tule elk. The Olema Valley population was eliminated by the mid 1800s as agriculture, logging, hunting and development increased dramatically due to the gold rush (Seashore 1998; McCullough 1969). There are numerous accounts of elk hunts in the literature.

As discussed in Gogan (1986) and Mason (1970), the most thorough description of the tule elk range prior to their extirpation was done by Lieutenant Joseph Warren Revere. Revere described an elk hunt in August of 1846. Revere noted that Mexicans were aware that the best time to hunt elk was in August because they were the fattest then (Gogan 1986) and that a herd of over 400 elk was sighted by an 1846 hunting party. Gogan (1986) suggests by Revere's observations that the slaughter of elk was extensive at that time. From Gogan (1986) quoting Revere –

> "The elk are very abundant at this season, and more easily killed than cattle. We passed many places, on our way back, where mouldering horns and bones attested to the wholesale slaughter which had been made in previous years by the rancheros of the neighborhood."

One of the earliest settlers of Point Reyes peninsula, Mr. P.J. Shafter came to Marin County in 1862 and by that time believed that tule elk had been extirpated from Point Reyes.

In 1978, 10 tule elk, two males and eight females, were moved to Point Reyes National Seashore from the San Luis National Wildlife Refuge and placed in a 1,052

hectare (2,600 acres) enclosed reserve on Tomales Point. As mentioned in chapter one, the tule elk range extends from the northernmost tip of the Point Reyes peninsula 5 miles southward with the southern boundary marked by a three-mile-long, 8-foot-high fence that separates the herd from surrounding active cattle ranches and is bordered on the west by the Pacific Ocean and the east by Tomales Bay (Gogan 1986; Seashore 1998; Howell et al. 2002).

The population grew slow at first due to mineral deficiencies, adult mortality, Johne's disease and reduced reproductive rates (Seashore 1998). Additionally, at the time the elk were introduced in 1978, they had to share the range with cattle, which led to increased competition for forage on the already degraded range. Cattle were removed from Tomales Point in 1980 paving the way for the elk population to grow (Seashore 1998).

There has been much debate over the tule elk population housed at the reserve on Tomales Point. Researchers have estimated the carrying capacity of the tule elk range to be between 140 and 350 elk based upon the available vegetation found within the habitat (Seashore 1998; Howell et al. 2002).

Since tule elk were reintroduced to Tomales Point, they have dramatically increased in numbers. The current population is estimated to be around 459 individuals (unpublished elk census 2008). In 1998, 45 elk were moved from the enclosed reserve on Tomales Point to the Limantour wilderness area within Point Reyes National Seashore and allowed to roam free. Some members of the Limantour herd eventually moved to D-Ranch on their own after being released from quarantine in 1999 (Gates pers comm. 2009).

Even though the current population is well over the hypothesized maximum carrying capacity of 350 individuals at the reserve, park managers have been faced with the dilemma of how to reduce the population in a way that is acceptable to the public. Hunting may be permitted at Point Reyes, although any killing of the elk is extremely unpopular with the local citizens (Seashore 1998; Howell et al. 2002). Park managers started to use contraception in 1997 as a way to manage the elk population at the reserve although that program ended in 1999 because funding was inadequate (Cobb pers comm. 2008; Pt. Reyes Light 2005). Presently park managers hope that the herd will reach equilibrium with the existing vegetation and naturally regulate itself (Seashore 1998; Cobb pers comm. 2008).

Tule Elk Life History

Tule elk cows give birth in late spring or early summer, (April to June) usually to one calf and rarely twins. Calves born at this time were conceived during the previous rutting (breeding) season which is not definite for Tomales Point tule elk, although mostly occurs from July to October (Seashore 1998; unpublished NPS data 2003). Rutting season behavior includes bugling vocalizations, which are high-pitched calls by males, body postures, sparring and fighting between males where injuries sometimes occur (Seashore 1998).

The sex ratio of calves is usually 50:50 at birth although females tend to live longer than males. Tule elk grow fast and reach sexual maturity by about 18 months. Adult female elk typically weigh 300 to 500 pounds with males weighing 50 to 100 pounds more than females (Seashore 1998). At age one-and-a-half, males develop

straight antlers and are referred to as spike bulls. With age, the antlers grow to have four or five points or more and they may weigh as much as 40 pounds (Seashore 1998). In February the antlers are cast off and males immediately start growing new ones (Seashore 1998; Cobb pers comm. 2008). This process of antler growing is nutritionally demanding for the male and is part of the reason why males do not live as long as females (Seashore 1998).

Tule elk breed polygamously with males competing during rut for reproductive dominance. The dominant bulls mate with groups of females by forming harems and actively guard the harem against other males (Seashore 1998). The most dominant males are typically between four and eight years old and they may go a month without eating to mate and keep out competitors (Seashore 1998).

Tule elk are considered mixed-grazers because they feed on grasses, herbs, woody shrubs and trees (Seashore 1998). Each elk will consume two to three-and-a-half pounds of vegetation per 100 pounds of body weight in a day. Therefore it is estimated that each individual elk will require three to ten acres of habitat to sustain itself, although this figure is inexact because it is context dependent (Seashore 1998). The tule elk at Tomales Point have few predators at the present time, although historically, black bears, grizzly bears, mountain lions and coyotes would have eaten sick, old and young elk (Gogan 1986; Seashore 1998). Currently only coyotes, mountain lions and bobcats are present on the range. Bobcats and mountain lions remain effective predators of tule elk calves, especially during years with low forage (Gates pers comm. 2009; Seashore 1998).

HUMAN HISTORY

The first humans to inhabit the Point Reyes peninsula were the Coastal Miwok and Pomo bands although human occupation in the area may go back as far as 11,000 years (Seashore 1998; Evans 2008). Coastal Miwok lived in the area as hunter-gatherers and relied on the cycle of the moon to tell them what foods were available (Evans 2008).

NPS estimated there were more Native Americans on the peninsula in 1500 than white people in 1960 (Point Reyes Land Use Survey 1961). At one time, there were 113 village sites located on Point Reyes peninsula, along the western shore of Tomales Bay, Drakes Estero and other coastal areas leading some to believe marine animals were a staple food product of the Miwok. In addition, acorns, fruits and berries were a staple for the Miwok people.

Most Miwok moved to the Mission San Rafael by 1820 leaving their land vacant. By that time, smallpox had killed an estimated 70,000 Miwok in Marin, Napa, Sonoma, Solano, Mendocino, and Humboldt counties (Mason 1970).

Point Reyes was visited by Spanish and English explorers in the 1500s and is thought to be the site of the first known landing of Sir Francis Drake in 1579, although there is some uncertainty over the precise site where Drake landed (Mason 1970; Seashore 1998).

The Portuguese explorer Sebastian Rodriguez Cermeno arrived on his ship the San Agustin on November 6th 1595 on his way to Acapulco. Cermeno took the point for the King of Spain – naming it La Bahia de San Francisco, which caused confusion with the real San Francisco Bay. The San Agustin would later shipwreck (Mason, 1970).

Another explorer named Don Sebastian Vizcaino arrived on January 6th 1603,

the day of the Three Holy Kings. Vizcaino was looking for the ship and cargo of the shipwrecked San Agustin but failed to find anything (Mason, 1970). Vizcaino named the bay the Puerto de los Reyes and the cape Punto de los Reyes in honor of the three kings of Cologne (Mason, 1970).

Point Reyes Ranching

Since Drake, many Europeans visited Point Reyes, although the point was not settled until 1834 by William Smith (Seashore 1998). Mexican land grantees brought cattle in the 1830s. The first settlers introduced cattle during what is referred to as the "rancho period" when two Mexican ranchos were established. The rancho period lasted about 25 years and by the gold rush in 1848 most of the land was owned by one American family.

The dairy and beef industry developed in 1857, became regionally important and prospered for over 100 years (Mason, 1970). Several dairies continue to operate within the park boundaries to this day.

The dairies of Point Reyes were among the first large-scale quality dairies in the state and the Shafter's butter district was considered to be the largest in the world. Prior to 1857, dairy products were shipped from the east coast to San Francisco or produced locally on small dairies of "questionable quality" (Mason, 1970).

Pierce Point Ranch consists of three former ranch sites – the lower Pierce Ranch site, demolished by NPS in the 1970s, the original Solomon Pierce homestead at White Gulch (no longer there) and the upper Pierce Ranch site (which still exists) (Livingston 1994).

Upper Pierce Ranch is located on a swale on Tomales Point with Tomales Bay to the east and the Pacific Ocean to the west. Access to Tomales Point and the ranch is along Pierce Point Ranch Road, which terminates at the parking lot for McClures Beach.

The ranch consists of 18 buildings all dating from 1860 to 1933. The ranch is no longer in use, but it has been listed on the National Register of Historic Places, has been restored and is open to the public with interpretive signage for self-guided tours. The main ranch house is presently occupied by park personnel (Livingston 1994).

The Pierce Point Ranch land was originally part of the Antonio Osio land grant tof 1843, Punta de los Reyes Sobrante, which was acquired by Shafter, Shafter, Park and Heydenfeldt in 1858 (Livingston 1994).

The firm then sold the 2,200-acre tract of land at the end of Tomales Point to Solomon Pierce for $7,000. In December of 1858, Solomon and his family moved to the ranch. Pierce settled in the valley of White Gulch on the north shore, invested in livestock and cleared 400 acres of his land (mostly coastal scrub). By the end of his first year he acquired $2,192 worth of ranch animals: three horses, 37 milk cows, two oxen, and 24 pigs that raised the value of the ranch to $8,000. Pierce Ranch produced 4,000 pounds of butter each year, which was second in volume on the peninsula.

In 1862 the ranch consisted of two buildings, a cultivated field and rows of planted trees all near the water at White Gulch. Between 1862 and 1868, Pierce constructed the ranch in the present site.

The ranch changed owners numerous times since the Pierces owned it. By 1966, then owner Dorothy McClure sold the ranch to the Bahia Del Norte Company. In 1973, Bahia Del Norte sold the property to NPS. In 1976, the ranch was designated as part

of the Phillip Burton Wilderness and two years later ten tule elk were reintroduced onto Tomales Point. Finally, Merv McDonald, who held a grazing lease before the Bahia del Norte sale, was evicted in 1980 along with his cattle (Gates pers comm. 2009).

CHAPTER 4- METHODS

Survey

Understanding the motivations of recreationists to visit a park can inform park managers about which groups pose the greatest threat to sensitive wildlife. Visitor motivations can be the underlying reason for different behaviors resulting in wildlife impacts. For instance, individuals that cite wildlife viewing as a primary motivation for visiting may be more likely to approach animals (Knight and Cole 1995). In addition, visitor perceptions of the effect they are having on wildlife can be useful for park managers in understanding ways to mitigate recreational impacts by encouraging low impact behaviors (Taylor and Knight 2003). Moreover, understanding the locations and concentrations of human-wildlife encounters within a park is essential to effectively mitigate potential negative effects that may result from such encounters.

Therefore, in the fall of 2008, the author devised a survey instrument that addressed the questions of visitor motivation, perception of recreation impacts and concentrations of recreational activity and encounters with tule elk (Appendix A). The author went to Tomales Point for five consecutive weekends (one Friday and the rest were Saturdays and Sundays) and surveyed a total of 185 people, although the survey went through several iterations so the majority of the responses analyzed were from the final draft survey completed by 121 people.

The survey was intended in part to determine what respondents considered appropriate behavior in the park because this would be informative as to whether there was a need for education. There were questions specifically pointed toward determining the distance respondents felt appropriate to keep between the elk and themselves and

whether they thought that human recreation had the potential to harm wildlife. In order to understand where their activities were located, they were asked to draw on a map - how far they hiked on the trail, where they saw tule elk and where they went off the main trail.

The survey provided both spatial and non-spatial information. Spatially, it gave two point sets (one of off-trail hiking and one of elk sightings) and one polyline set of the trip lengths on the trail. The point sets made it possible to get maps of concentrations of elk sightings and off-trail locations and the polyline set made it possible to create a map showing hiker concentrations on the trail. All of the spatial data was entered into a geographic information system (ArcGIS 9.3, ESRI 2008) to process the information and display it in a visual format.

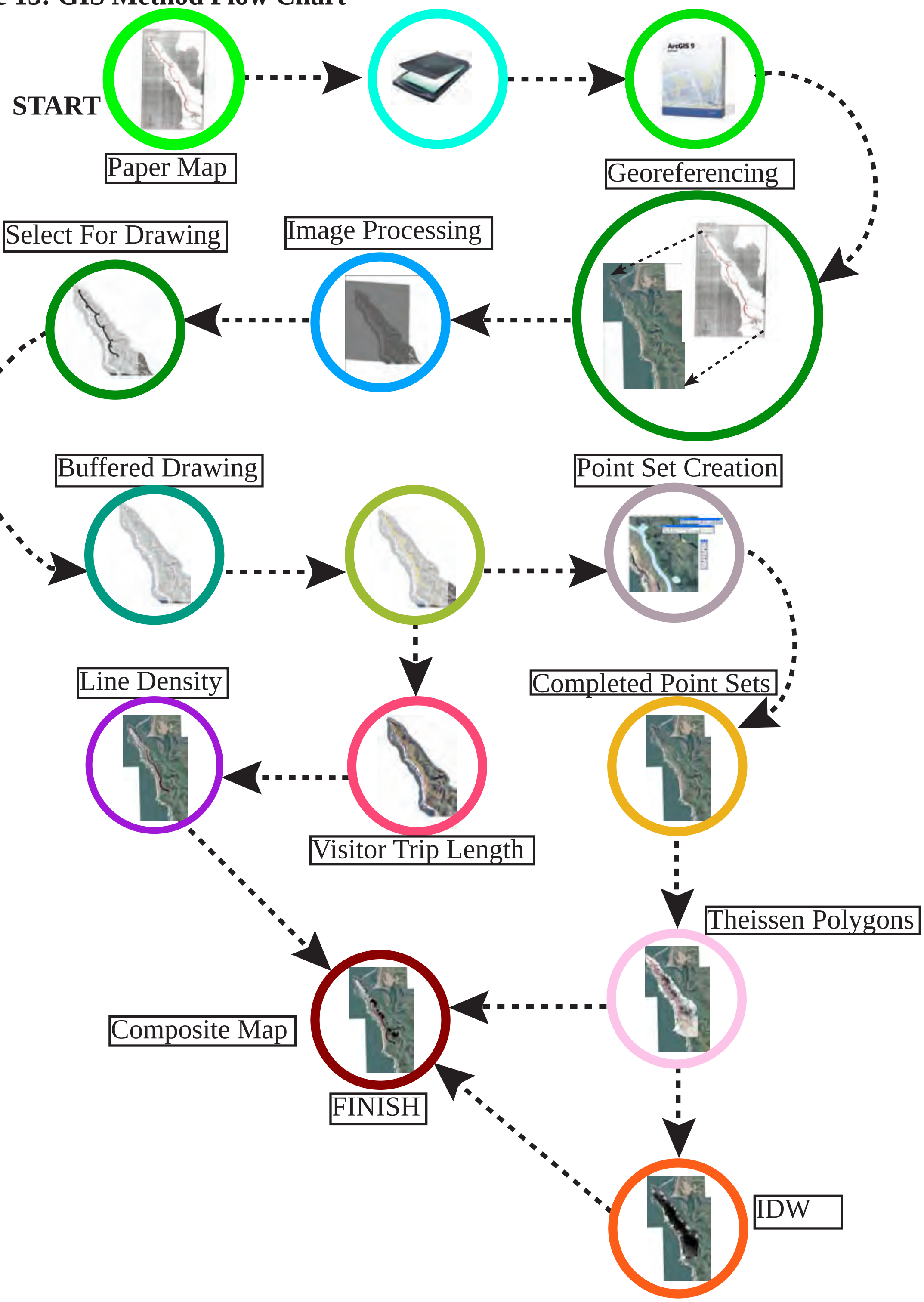
Non-spatial information gathered from the survey included visitor motivations, demographics, experience with and time spent at Tomales Point. This information provided a sense as to what the typical Tomales Point visitor was like (see chapter 5).

GIS Analysis

As mentioned above, part of the survey involved the respondent marking on a map how far they hiked on the trail, where they saw tule elk and where they hiked off-trail. The spatial information was processed in a geographic information system (GIS). A GIS is a system of software, hardware and data that is used to integrate different spatial data and associated non-spatial data so that it may be analyzed as a whole (ESRI Spatial Dictionary). Spatial relationships are more easily understood using a GIS because it creates a visual representation of your data and projects it over the earth's surface. GIS was particularly useful for understanding where the concentrations of people and elk

were and identifying areas of potential conflict. The method used for the GIS analysis is outlined below.

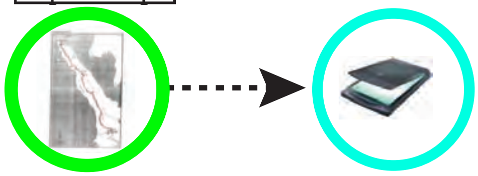
Figure 13: GIS Method Flow Chart*



*GIS ANALYSIS: Started with a paper map from the survey and end with a composite map showing the areas with the highest concentrations of people and elk.

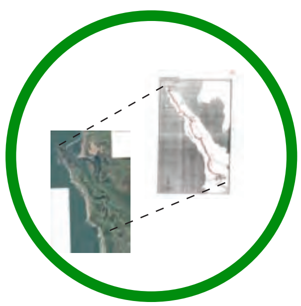
GIS Analysis Step-by-Step Outline

Paper Map



1.The paper maps were scanned at a resolution of 150 pixels per inch.

2. The maps were imported into ArcGIS 9.3 (ESRI 2008) in raster format.



Georeferencing

3. The maps were georeferenced one at a time onto Tomales Point. In other words, the ArcGIS software was used to specify the location on the earth's surface where the activities on the survey map occurred.

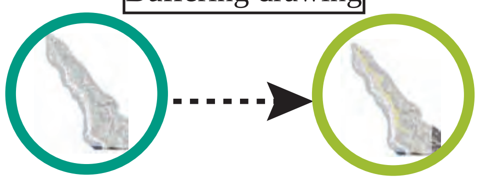
Image Processing

4. A method had to be determined to separate out what the respondent had drawn on the map from the rest of the map so that all of the different activities could be combined as a whole in a GIS. Therefore, the rasterized survey map was converted into points.

Select For Drawing

5. The places where respondents marked their activities on the survey map had a unique grid code. Therefore it was possible to select for only the respondent's drawings by selecting where the grid code value was less than 255. The distance travelled on the trail, locations where they went off-trail and locations where they saw elk were now captured.

Buffering drawing



6. Once the drawings were selected, it was necessary to convert the points into polygon format in order to extract how far respondents hiked on the trail. Since buffering required drawing a buffer around thousands of points, this process was processor intensive and required two steps. Therefore a five-meter buffer was created and then the 5-meter buffer was buffered by 30 meters. Buffering the original data by 35 meters accounted for some of the respondent error that may have occurred when trying to recall where their activities occurred on the map. In addition, as mentioned above, the 35-meter buffer was used to extract (clip) how far people hiked on the trail (see step 7 below).

Visitor Trip Length

7. The buffered trail drawing from above and a layer depicting Tomales Point trail, was used to subtract the distance travelled by the respondent from the entire trail length.

Point Set Creation

8. The buffered trail and buffered activities drawing from above were used to mark (with points) the places that respondents indicated seeing tule elk and where they went off-trail using the editor toolbar.

Line Density

9. All of the distance travelled polylines (from step 7) were combined into one polyline set (n=138). Then using the line density tool in the spatial analyst extension in ArcGIS, a map was created showing the concentrations of hikers on the main trail. A grid is placed over the area of study. The density of the entire polyline set is calculated by placing circles around each grid cell, summing the length of lines running through each circle and dividing by the area of the circle.

Completed Point Sets

10. Now there are two points sets, one for off-trail hiking locations (n=77) and one for elk sightings distributed over Tomales Point (n=359).

Thiessen Polygons

11. The point sets were then used to get a density metric using Thiessen polygons resulting in a discrete surface created from known points. All locations within a given

area is associated with the nearest member of a point set. The resulting surface is partitioned into a set of regions, or polygons representing area per point. The smaller polygons indicate increased point density. Thiessen polygons are useful as an unbiased density metric. The point per area density metric is inherently full of error because a person must decide what area to focus on. Thiessen polygons remove this error by assigning area to each point in a discrete point set instead of assigning points to an area chosen by a human (Okabe et al. 1992).


IDW

12. In addition, Inverse Distance Weighting (IDW) was used to interpolate between known points to show probabilities or trends in each point set. IDW creates a continuous surface by interpolating between sample points. IDW estimates the values of unknown points in space as weighted averages of known points, giving the greatest weight to the nearest points. In the resulting surface, the value at any given point in space is most like the values of nearby points than distant points (Longley et al. 2001). IDW is useful in situations where sample points may be limited and one is interested in seeing what the surface may have looked like if one had been able to collect more data.

Once an elk sighting concentration map, an off-trail hiking concentration map and an on-trail hiker concentration map were created, all three maps were combined to see where the areas of potential conflict were.

Composite Map

13. Finally, the symbology tab in the layer properties of the elk sightings IDW and the off-trail locations IDW was used to manually select the areas of highest concentration for comparison. In addition, the on-trail hiker concentration map that was created using the linear density tool was overlaid onto the elk sighting and off-trail location maps. The result was a composite map showing three distinct areas of potentially high interaction between hikers and elk (see figure 24).

CHAPTER 5 RESULTS

Survey Results

The survey questions could be categorized into motivations and recreation experience at Tomales Point, perceptions of human recreation impacts and respondent demographics.

Motivation/Experience

The majority of people indicated that hiking was the main motivation for them to visit Tomales Point (92%). The second most common motivation was to see the tule elk (66%), followed by 52% of people who said spending time with family and friends (see figure 12).

When asked to rank how important particular experiences were to them, hiking and exercise once again ranked the highest. Respondents were asked to indicate on a Likert-type scale from 1 (not important) to 5 (very important) how important different experiences were to them. People rated being in a wild, undeveloped place as the second most important, spending time with family and friends as the third most important and seeing the tule elk fourth (see figure 13).

In addition, the majority of people hiked in groups of two, most spent three to four hours on the trail and most were first-timers to Tomales Point.

What Does it Mean?

Two-thirds of respondents indicated that seeing the tule elk motivated them to visit Tomales Point. While viewing the tule elk ranked fourth in order of importance, the experience was still a main driver for people to visit Tomales Point. Wildlife enthusiasts in general are more likely to be excited when they come across tule elk and may be more

Figure 14: Visitor Motivations for Visiting Tomales Point

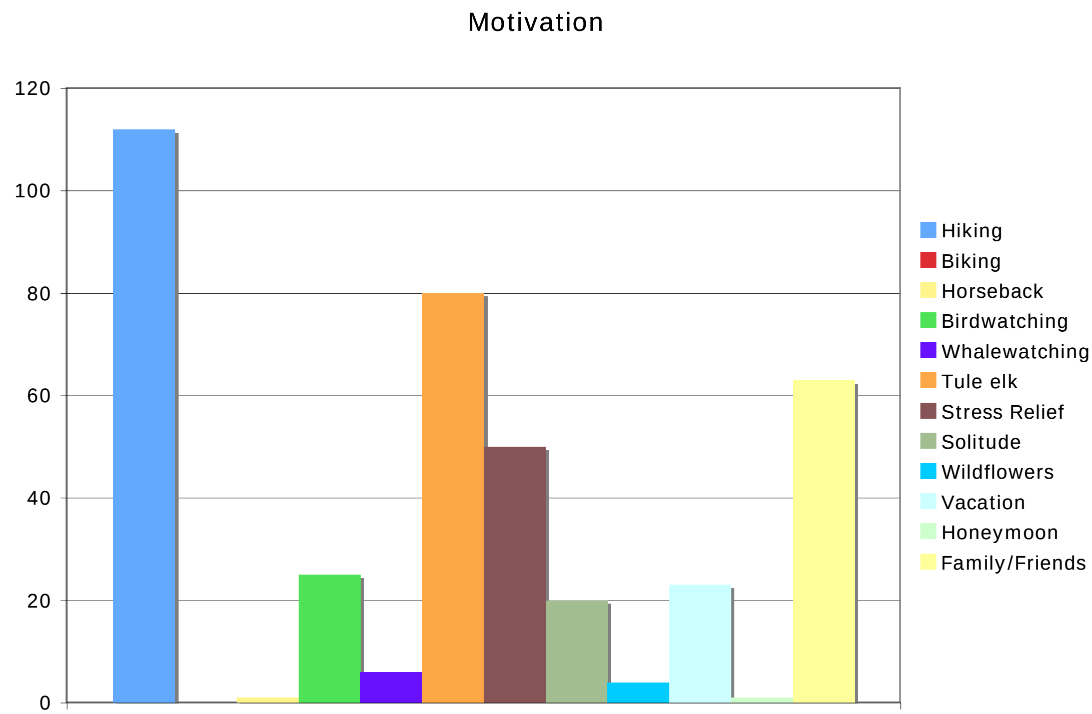


Figure 15: Ranked Motivations (summed from a 1-to-5 Likert-type scale)

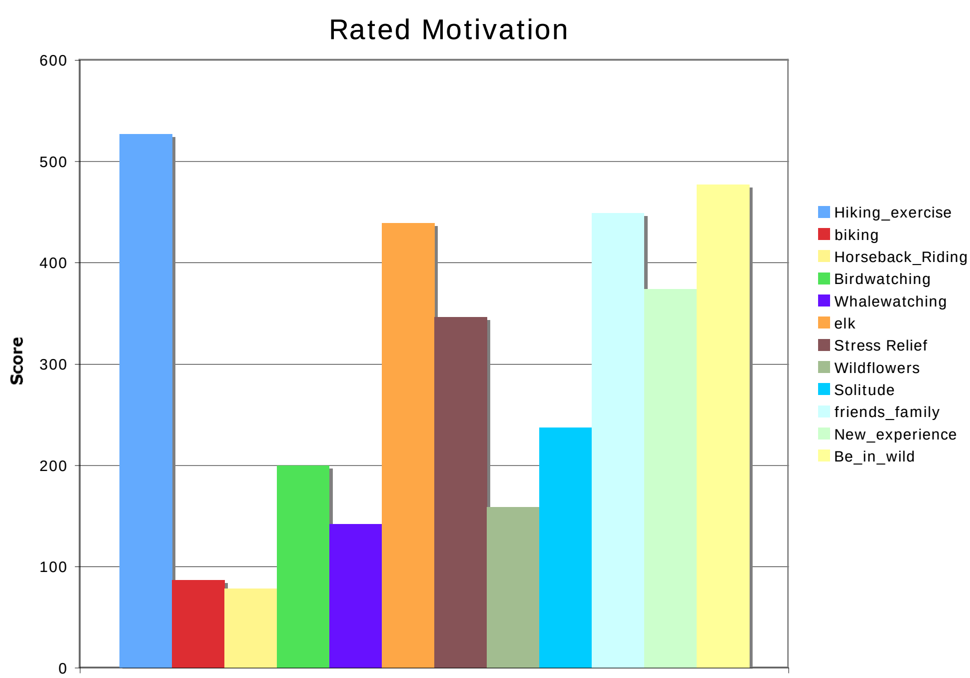
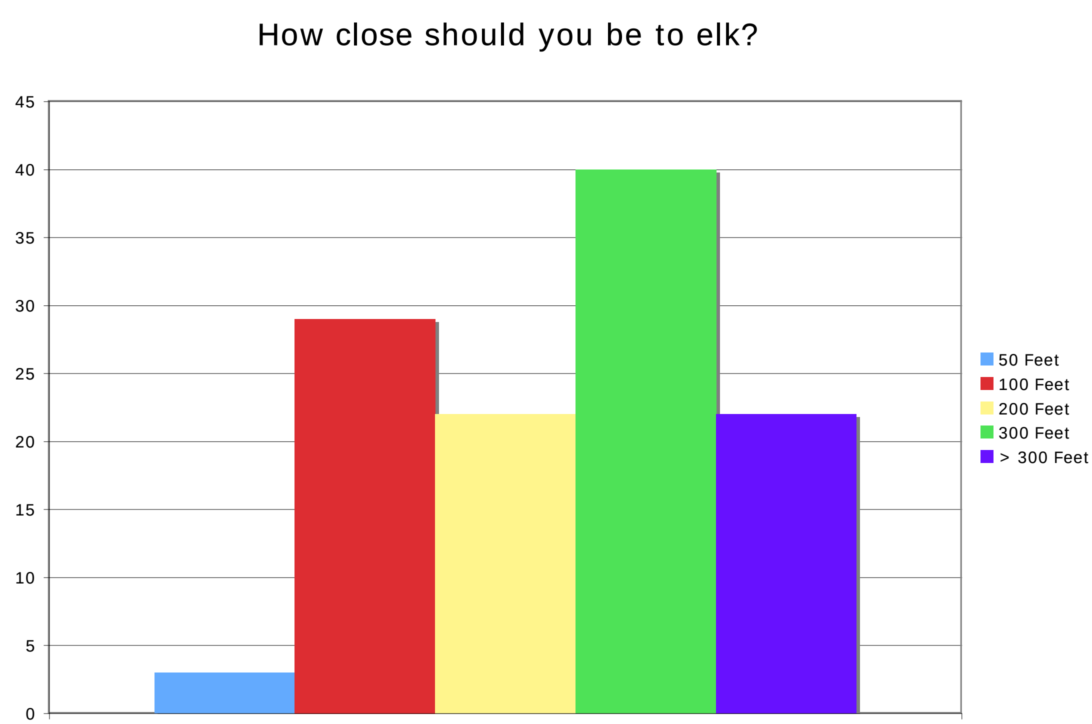


Figure 16: Visitor Off-trail Frequency (when hiking anywhere)

Figure 17: The Distance Visitors Thought Was Adequate to Keep Between Elk and Themselves



likely to walk off-trail to get a closer look at the elk.

Perception of Human Recreation

Most people indicated that they occasionally or rarely go off-trail (see figure 14) and most people agreed that human recreation has the potential to negatively impact wildlife (see figure 15). The results of the off-trail frequency and human recreation impact questions were surprising because it was expected that people who went off-trail more would have been less likely to agree that human recreation may negatively impact wildlife. The answers to these questions may have been skewed by respondents in an attempt to choose the "socially desirable" response regardless of how truthful it was (Edwards 1957).

Thirty-one percent of respondents reported hiking off-trail on the day of the survey. Although as with the off-trail frequency and recreation impact questions, respondents may have been tempted to go with the more socially acceptable response of not going off-trail.

Thirty-four percent felt that 300 feet was an appropriate distance to keep between elk and themselves followed by 24% who felt that 100 feet was adequate. Over half (57%) of respondents indicated they are actively looking for wildlife when hiking. And when asked to estimate the closest they were able to get to the elk, the average distance reported was 270 feet.

For those that reported going off-trail to get a closer look at tule elk, over half agreed that human recreation has the potential to negatively effect wildlife, 63% actively look for wildlife and the average distance travelled off-trail for the group was 83 feet.

What Does it Mean?

While most people indicated that they only rarely, or occasionally go off-trail, almost a third of the respondents reported going off-trail to get a closer look at the tule elk. In addition, while more people indicated 300 feet as the most appropriate distance to keep between elk and themselves, all answers to this question were spread relatively evenly across all categories with the exception of 50 feet (see figure 17). This may suggest that there is some uncertainty among recreationists at Tomales Point regarding the appropriate distance to keep between elk and themselves. Park managers should determine what is an acceptable minimum distance that people should keep between elk and themselves at all times and illustrate the distance using a prop (see chapter 6).

Demographics

The vast majority of people travelled from the Bay Area to Tomales Point. Both sexes were equally represented. An overwhelming majority had some sort of college degree. 32% had a 4 year degree and 31% had a Master's degree.

What Does it Mean?

Recreationists at Tomales Point are highly educated which is consistent with other wilderness research (Ramthun et al. 2000). People with higher education were more likely to go off trail which was unexpected (see chapter 6). Visitors to Tomales Point may be highly educated, however, they are not necessarily educated in how to minimize recreational disturbance of wildlife. More research needs to be done comparing the findings of my survey with actual visitor behavior.

FACTOR ANALYSIS

To explore the relationships between different survey variables (motivations, perceptions, demographics), a factor analysis with varimax rotation was conducted (Becker 2009).

Possible relationships between the following variables were explored:

- Attitude towards human impacts on elk
- Closest distance that people got to elk and feel is acceptable to get to elk
- Feelings about reasonable management actions
- Did they go off trail that day?
- In general, how often do they go off trail?
- Motivations (hiking, tule elk) and off-trail hiking frequency and agreeing with the human recreation impacting elk
- Education level and whether they went off trail
- Education level and feelings toward human recreation impacts

The analysis produced groups of correlated survey variables (or factors). Each column (or factor) in figure 16 below (in shades of orange) is a natural group and those answers were correlated with each other.

In Group 1, people who were interested in one of the activities were generally interested in all of them. These people were generally different from the other three groups. Group 2 were people who were at Tomales Point to see elk, be with friends, and have a new experience. Group 3 indicated that more educated people were at Tomales Point more times, were more likely to go off trail, and were older. In Group 4, group size was negatively correlated with the other factors. People in Group 4 were in smaller

groups, wanted to be in a wild, undeveloped place and agreed that human recreation can negatively affect wildlife.

Figure 18: Factor Analysis Group Table*

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
	STRESS RELIEF	ELK	EDUCATION	BE_IN_WILD
	FLOWERS	FRIENDS	TIMES_AT_TP	REC_IMP
	SOLITUDE	NEWEXP	OFF_TRAIL_FREQ	GROUP_SIZE
	BIRD		AGE	
	WHALE			
FACTOR VARIABLES				
ELK	0.30	0.56	0.19	-0.02
STRESS RELIEF	0.59	0.31	0.01	-0.09
FLOWERS	0.83	0.09	-0.11	0.05
SOLITUDE	0.60	-0.13	-0.23	0.38
FRIENDS	-0.01	0.75	0.00	0.03
NEWEXP	0.30	0.63	-0.36	0.15
BE_IN_WILD	0.18	0.41	-0.07	0.65
BIRD	0.67	0.14	0.36	-0.02
WHALE	0.64	0.03	0.02	0.10
REC_IMP	-0.10	0.09	0.02	0.62
EDUCATION	-0.30	0.33	0.43	0.14
GROUP_SIZE	-0.19	0.26	-0.14	-0.61
TIMES_AT_TP	-0.14	-0.12	0.68	0.09
OFF_TRAIL_FREQ	0.17	0.20	0.47	-0.06
AGE	0.11	-0.37	0.54	0.00
% variance explained	**17.7**	**13.1**	**10.2**	**9.4**

*Values are correlation coefficients. The squared coefficient is the percentage of variance in the variable, explained by a factor. The factors move from strongest (factor 1) to weakest (factor 4). Blue boxes indicated weaker, secondary correlated variables. Generally a coefficient of at least 0.40 is needed to be considered strong. A total of 50.4% of the variance was explained by the 4 factors (Becker 2009; http://www.unesco.org/webworld/idams/advguide/Chapt6_3.htm).

GIS ANALYSIS RESULTS

Using Thiessen polygons to show point density, the resulting map is shown below for both the elk sighting point set and off-trail location point set. The darkest areas show highest density and the lightest areas show lowest density (figures 17 and 18).

Using Inverse Distance Weighted spatial interpolation, trends in the point set are shown below in figures 19 and 20. The darkest areas show highest density and the

lightest areas show lowest density.

Thiessen Polygons and Inverse Distance Weighting interpolation are good methods to use for interpolation between points, however they are not as useful for extrapolation. Both Thiessen polygons and IDW create surfaces that radiate out from the known point distribution. Therefore, the farther away from the point distribution (on the fringe or edge) the less accurate Thiessen polygons and IDW become.

The line density tool in the ArcGIS 9.3 spatial analyst extension was used to show on-trail hiker concentrations and the resulting map is shown below. The darkest part of the line shows the highest concentration of hikers on trail, while the lightest areas show the lowest concentration (see figure 23).

Finally, a composite map was created, which combined the elk sighting concentration, off-trail hiker concentration and on-trail hiker concentration maps (figure 24). The areas where red and black clusters overlap, or are close to each other indicate areas of highest potential conflict with the largest clusters indicating the highest possible occurrence. The areas of White Gulch, Avalis Beach and an area in-between them are shown as areas of interaction and park managers should focus on management actions that will address the potential negative effects of recreationists disturbing elk in their core habitat.

Figure 19: Density of Elk Sightings Using Thiessen Polygons

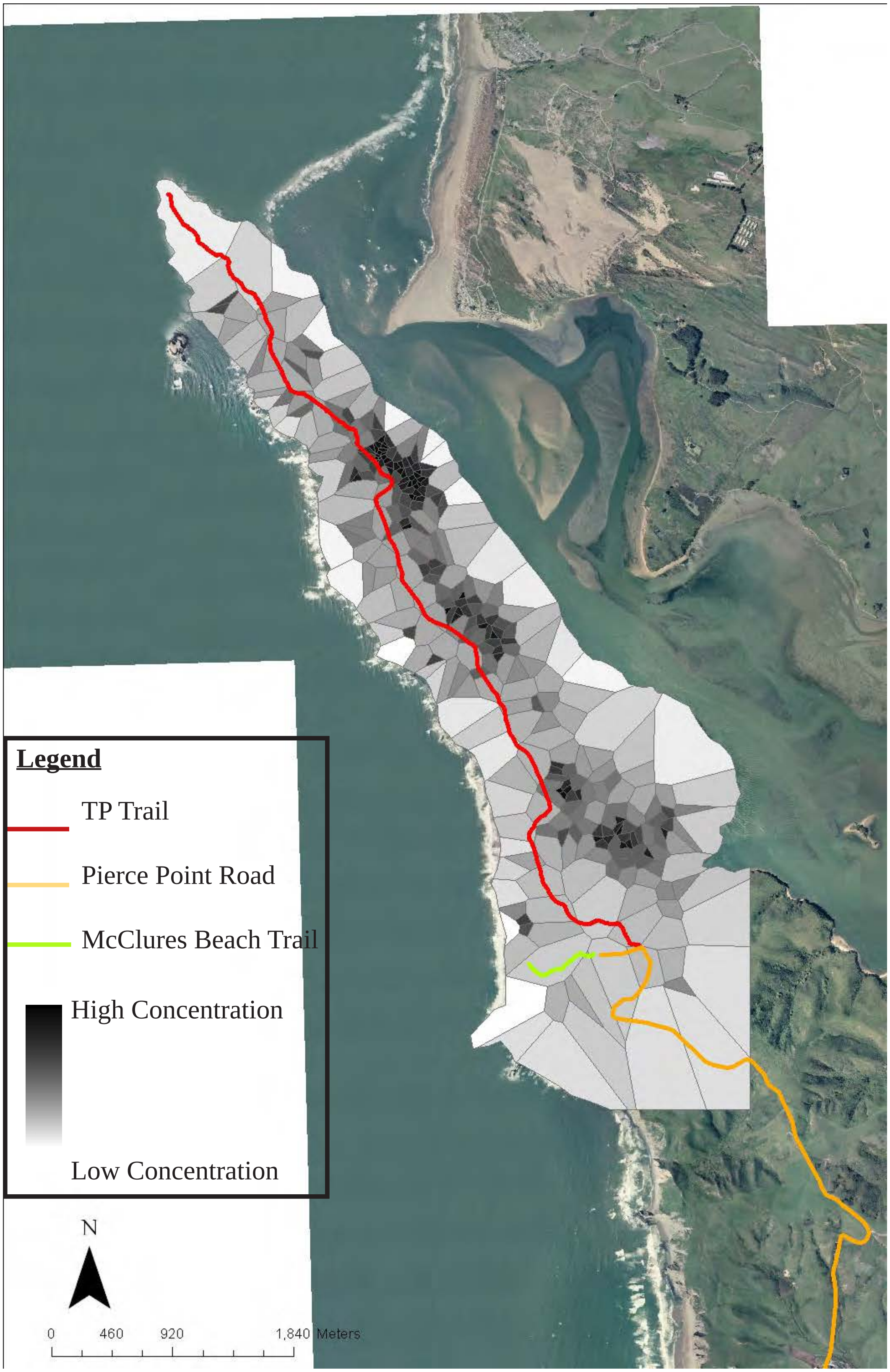


Figure 20: Density of Off-trail Hiking Locations Using Thiessen Polygons

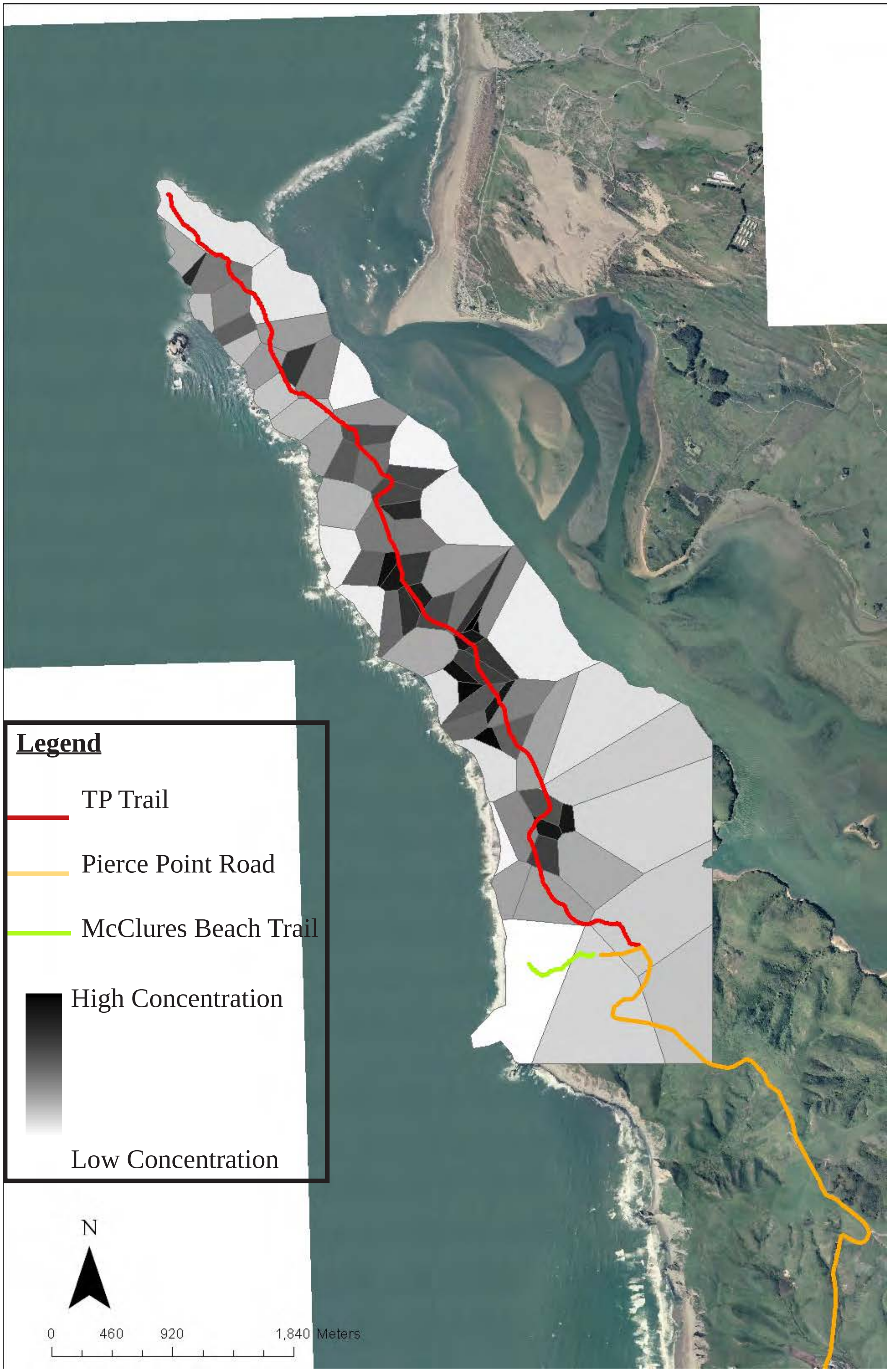


Figure 21: Trends in Elk Sighting Concentrations Using Inverse Distance Weighted Interpolation

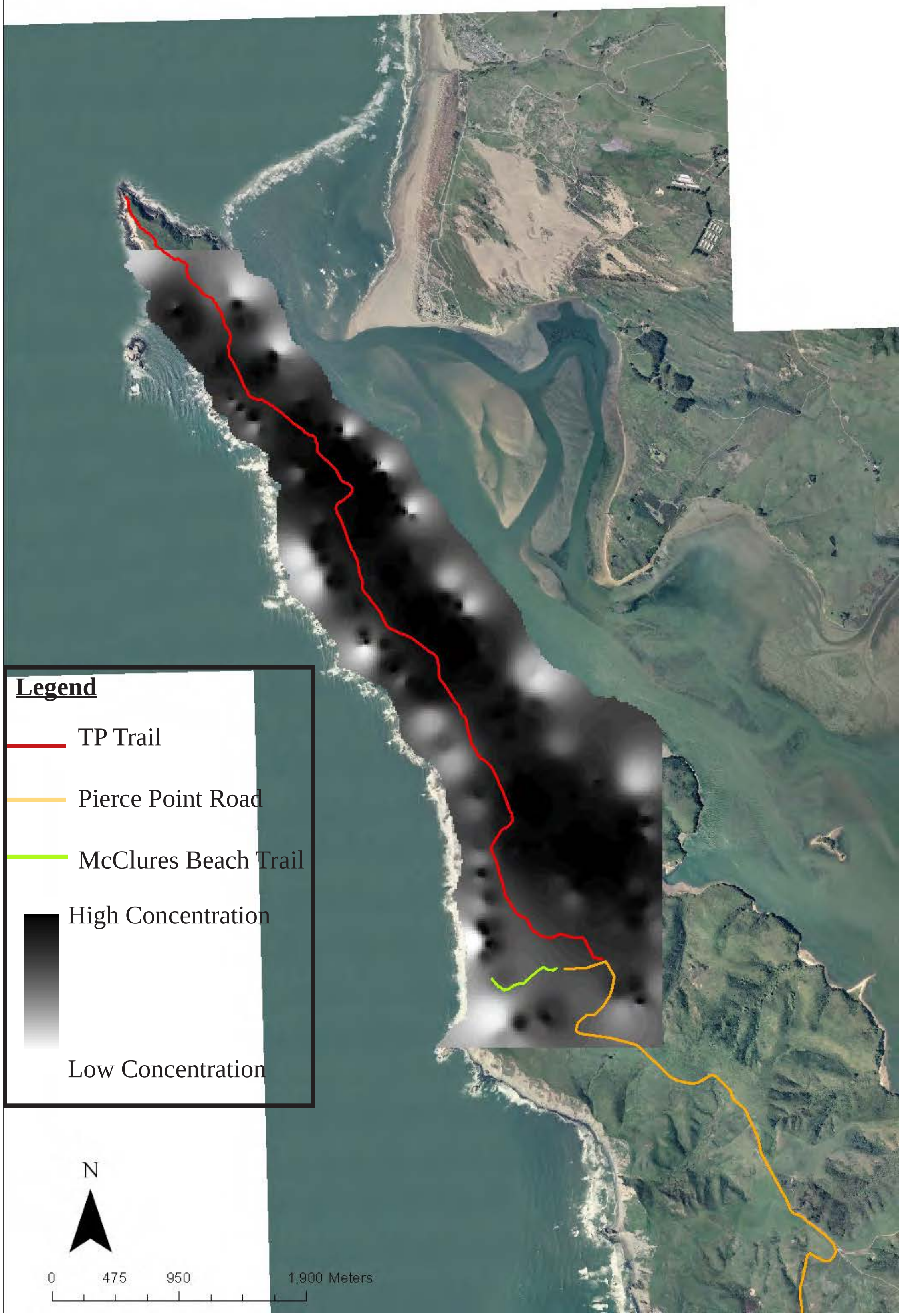


Figure 22: Trends in OFF-Trail Hiking Locations Using Inverse Distance Weighted Interpolation

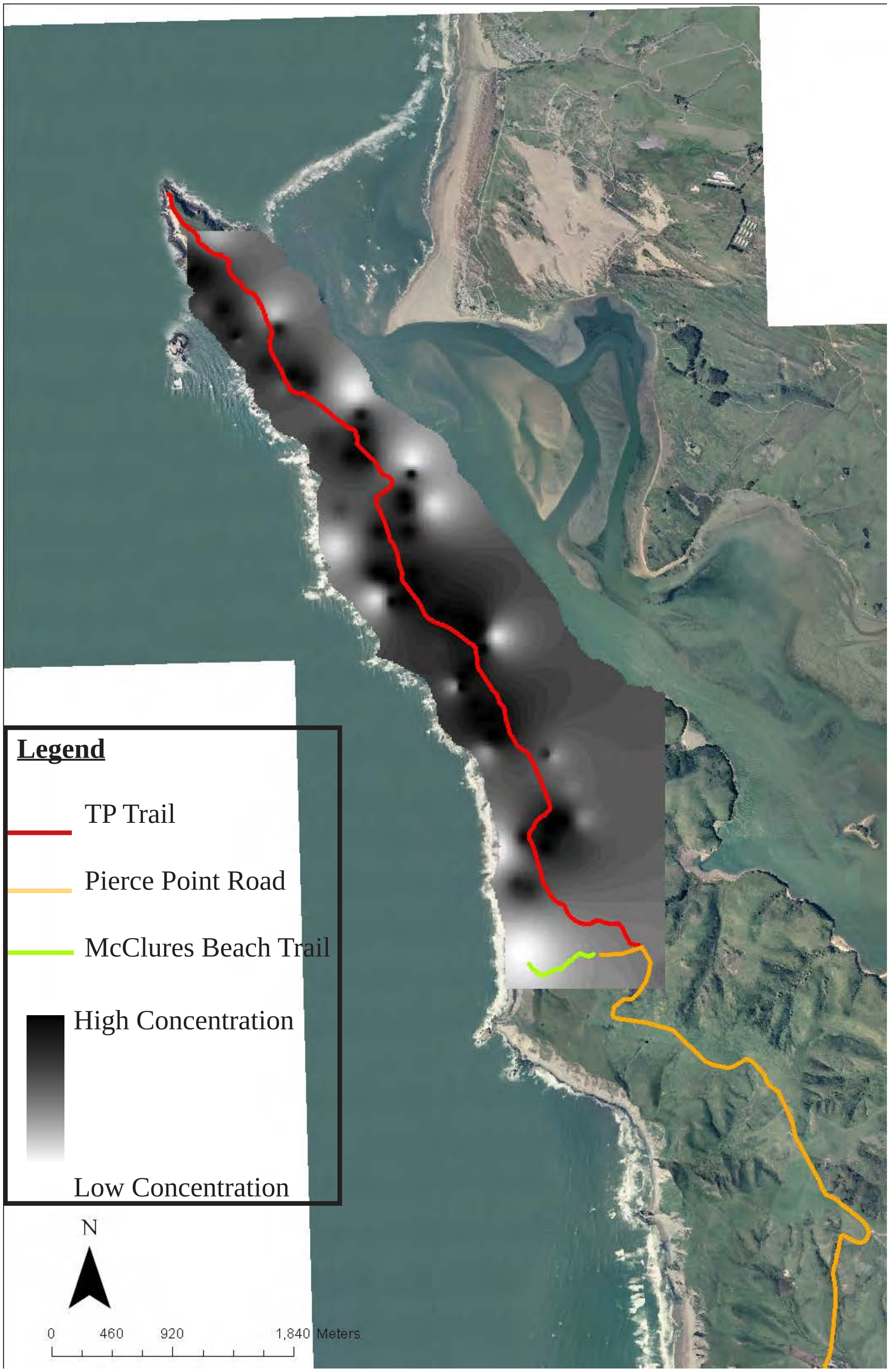


Figure 23: On-trail Hiker Concentrations Using Spatial Analyst Line Density Tool

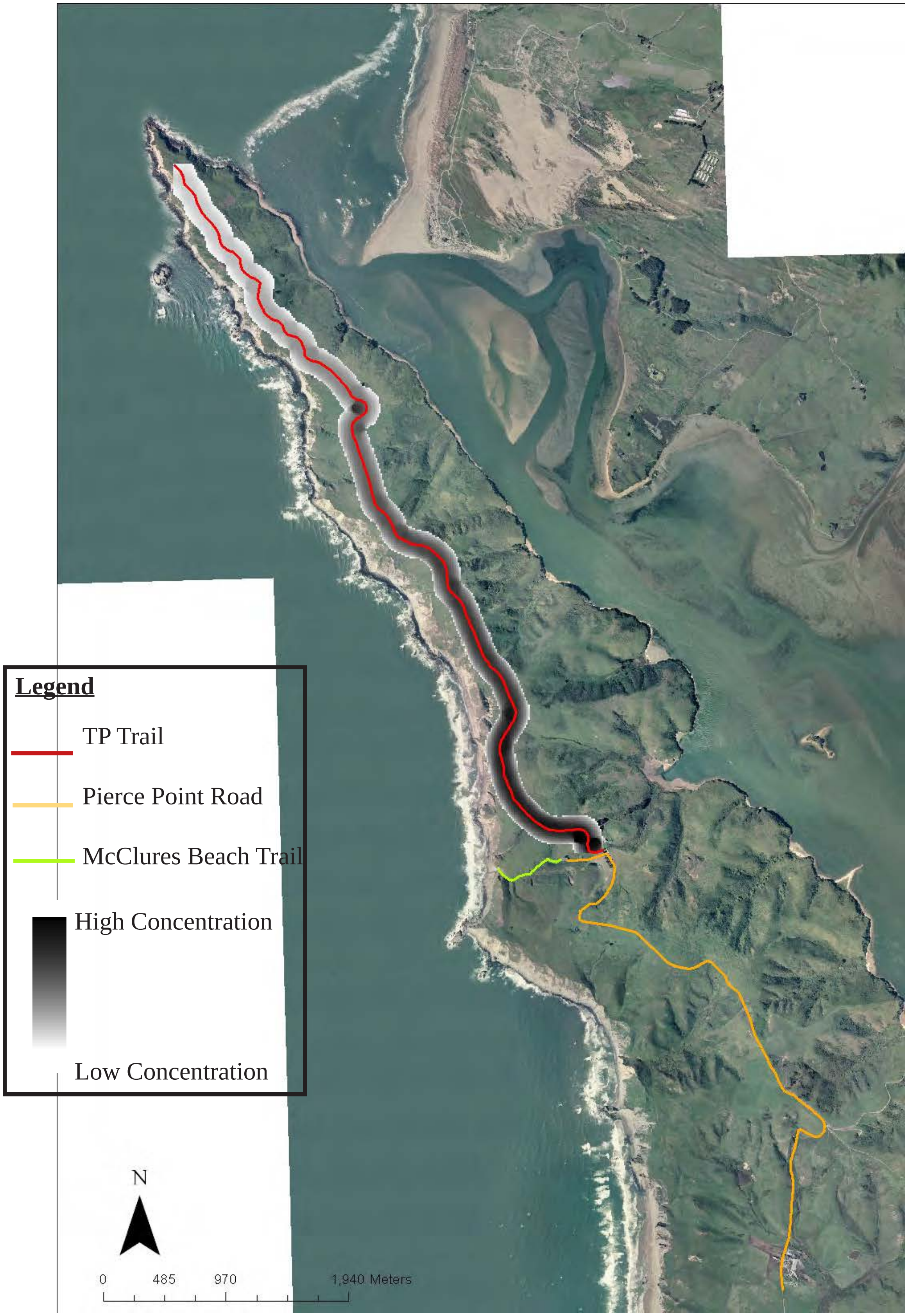
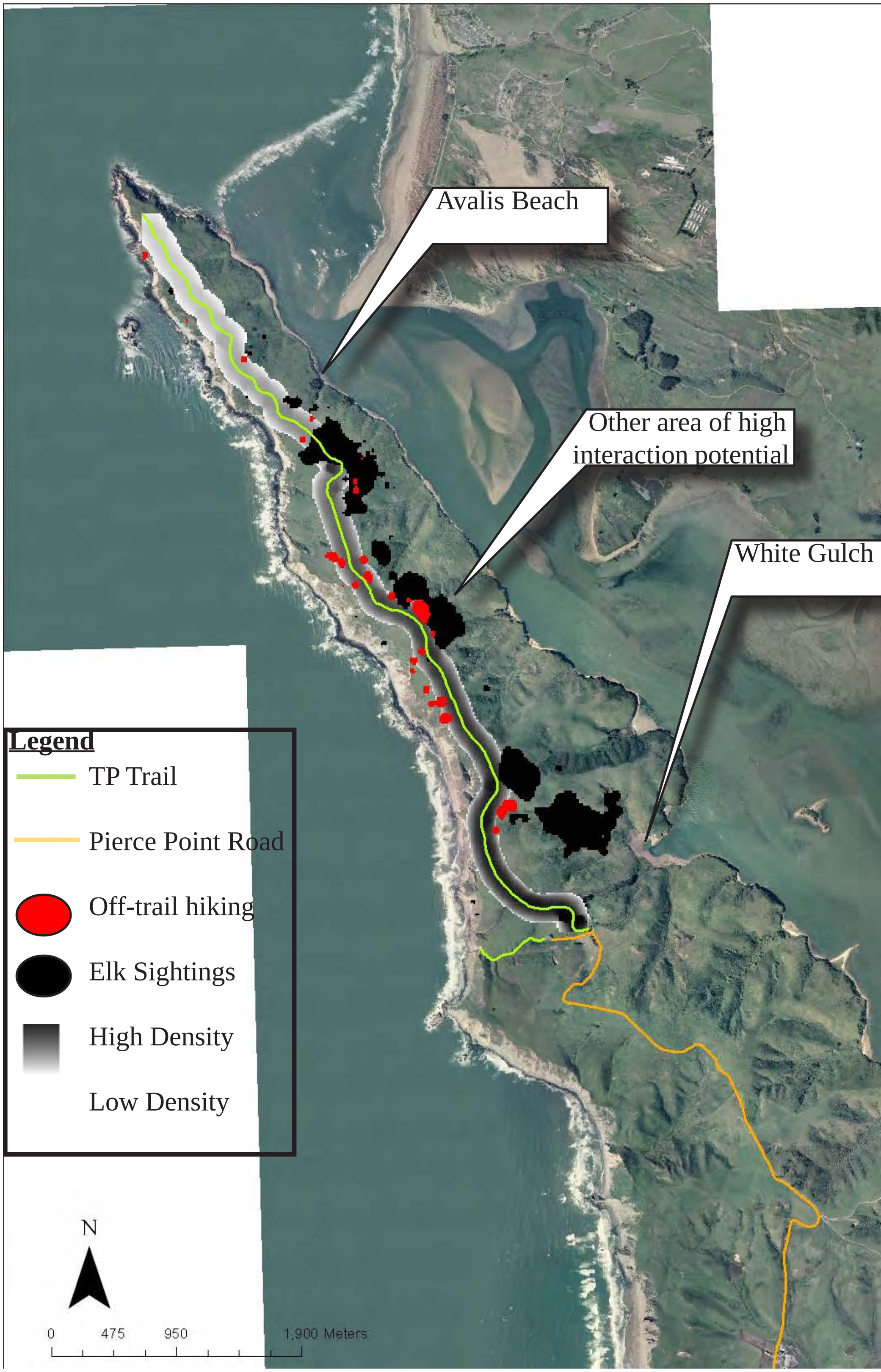


Figure 24: Composite Map of Elk Sighting Concentration IDW, Off-trail Hiking Location IDW and On-trail Hiking Concentration (Line Density) Showing Areas of Highest Interaction Potential between Tule Elk and Hikers



CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

The National Park Service is mandated to balance recreation and conservation. At Tomales Point, park managers are particularly concerned because the tule elk are confined to a reserve, they seem to use only certain areas of the reserve to breed and take care of young, and there is a high visitation rate. Park managers are concerned with hikers going off the Tomales Point trail and causing the elk to alter their behavior and leave prime habitat for more marginal areas.

This study used a visitor survey and GIS analysis to investigate hiker motivations and identify areas of potential elk-hiker interaction. Analysis of the survey responses indicated that new management action is supported by the majority of Tomales Point visitors. Furthermore, the three most popular management actions had a strikingly similar level of support.

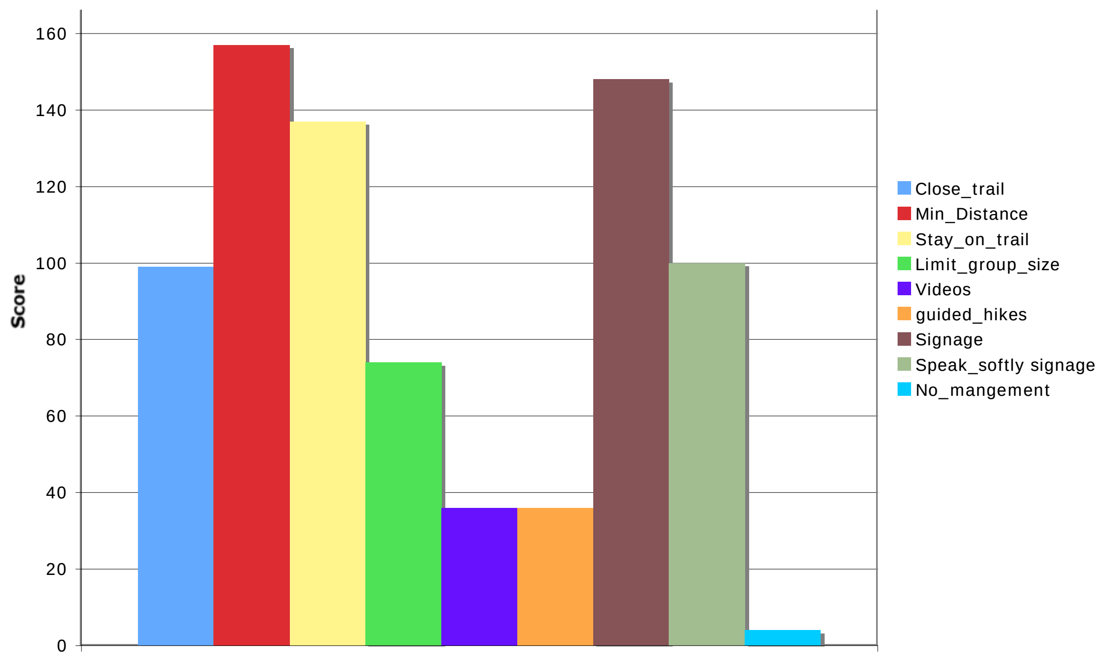
When asked on the survey what new management actions visitors would support, requiring people to keep a minimum distance between oneself and elk was the most popular (n=157), followed by new signage discussing elk ecology (n=148) (see figure 25). The third most popular was requiring people to stay on trail (n=137), and the fourth most popular was using signage to encourage people to speak softly and closing the trail during times of the year when elk are most sensitive. Also worth mentioning is that nearly 100 visitors supported trail closures where and when impacts were greatest to the tule elk and fewer than 5 people supported no new management actions.

Visitor supported management actions and results from the GIS analysis were used to make recommendations to the Park Service on how to reduce the potential conflict between hikers and tule elk at Tomales Point.

The survey and subsequent GIS analysis were used to identify the areas near White Gulch and Avalis Beach and an area in between as areas where high concentrations of visitors and elk sightings occur (see figure 24).

Relative uncertainty among survey respondents regarding how close they should be to the elk, along with the paucity of information on the elk themselves and appropriate wilderness behavior, suggests an immediate need for more signage at Tomales Point.

Figure 25: Visitor Supported Management Actions



Park managers should determine what a minimum "appropriate" distance should be to keep between visitors and elk. Further study may be necessary to determine this, however, it should be a distance that can be reasonably accommodated through use of a prop for illustrative and interpretive purposes. Park management should focus on indirect methods of visitor impact management before implementing more costly, potentially unpopular direct methods such as trail closures, trail redesign or increased staffing.

Managers must determine what impact thresholds are acceptable at Tomales

Point. Once thresholds are identified, it will be easier to decide what management action to take. Resource health goals should be set to determine if undesirable effects are resulting from human use.

At Año Nuevo State Park, a successful management program has been implemented to ensure that recreational impacts are minimized on the resident elephant seals. At Año Nuevo, there are docent guided tours during the seal breeding season. Tickets must be purchased for a guided tour of the seal rookery. There is a staging area before the trail that leads to the seal rookery with educational and interpretive materials dealing with seal ecology.

Figure 26: Buoy Used at Año Nuevo State Park to Illustrate People Should Be At Least 25 Feet From Elephant Seals At All Times

It is mandated that people remain at least 25 feet away from the seals at all times. To illustrate what this distance looks like, there is a buoy placed 25 feet from the trailhead gate (see figure 24). This is an effective, low cost, low impact tool to encourage appropriate behavior that could easily be implemented at Tomales Point.

In addition, another low cost measure that could be implemented right away would be to move the current tule elk sign that is located at the exhibits area off Pierce Point Road to the trailhead (see figure 6). While the sign should be supplemented

with additional, more current information, it matches the signs that are presently at the trailhead and could be added at little cost. The sign would be viewed more often at the trailhead and would in turn educate more people about the interesting past of the tule elk.

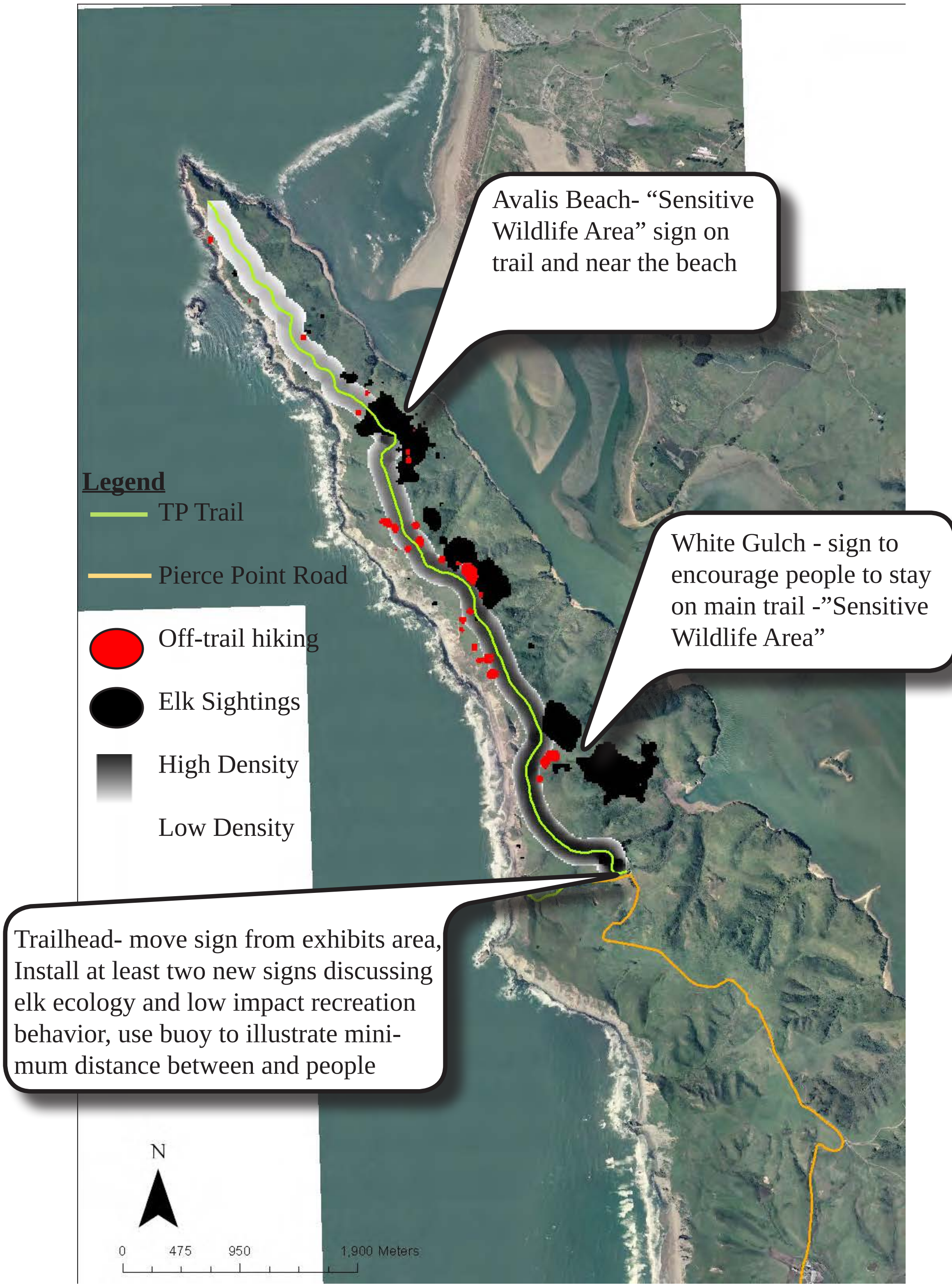
The sign should be supplemented with information about Tomales Point being part of the Phillip Burton Wilderness, and how visitors should engage in low impact, "leave no trace" types of behavior in such places, especially the places identified as potential conflict areas.

There should also be additional information regarding the tule elk life cycle. The breeding and calving season are times where the elk are particularly vulnerable to recreational impacts and visitors should be aware not to disturb the elk during these sensitive times of the year. A map showing Tomales Point with both Avalis Beach and White Gulch as areas of high-value habitat could be used to encourage people to leave the elk undisturbed in these areas and admire them from a distance rather than moving off-trail to get a closer look.

There should be at least one small wooden sign installed at White Gulch near the spur trail and near Avalis Beach on the main trail. An additional sign could be used to replace the aging signs near the beach at Avalis (see figure 27). These small wooden signs could say something like "Sensitive Wildlife Area: Please Keep Out". A small oak wooden sign would cost about $17 and $1.55 per one inch character (Wolfenbarger 2009).

At the trailhead there should be additional signage installed. As mentioned before, the tule elk sign that is currently in the "exhibits" area could be moved down to the trailhead at little to no cost. At least two additional signs should be installed at the

Figure 27: Suggested Locations for New Signage



trailhead encouraging low-impact behavior and educating people about White Gulch and Avalis Beach being sensitive tule elk habitat. The original tule elk sign could be supplemented with additional information about tule elk breeding and calving seasons and how recreationists should be careful not to disturb the elk during these important times of the year.

The main user group at Tomales Point is hikers. McCool and Cole (2000) found that hikers are more likely to stop and read information on signage than any other user group. Moreover, results from the survey indicate that the majority of visitors are visiting Tomales Point for their first time. McCool and Cole (2000) found that the more experienced hikers are with a place, the less likely they are to stop and read signs. Therefore the combination of having mostly hikers and people inexperienced with Tomales Point may be an ideal situation to use signage to educate people.

In their analysis of research on the efficacy of low impact visitor education programs, Marion and Reid (2007) reported that most studies indicated educational interventions such as trail signage were effective in reducing depreciative visitor behavior. However, to be most effective, low impact messages must be brief, consistent and targeted to the intended audience (Marion and Reid 2007).

A bulletin board sign could be added to take the place of the existing sign discussing elk calving season (see figure 28). The bulletin board sign could include a bigger map of Tomales Point discussing White Gulch, Avalis Beach and the other area identified in this report as places where people should not disturb the tule elk by going off-trail, especially during breeding and calving seasons.

Bulletin-board-style signs start at about $500 each for a 48 inch x 48 inch sign. A

Figure 28: Current Bulletin Board Sign at the Trailhead with information about tule elk calving season. A larger, more formal bulletin board sign could take the place of this one with additional information about elk breeding season and sensitive habitat areas.

sign with a map would be an additional $165 for an 18 inch x 22 inch map. However, the pricing of these signs also depends on the sign material and what is included on it. Additional information on wildlife could add to the cost of the bulletin board depending on how much text is used (Wolfenbarger 2009).

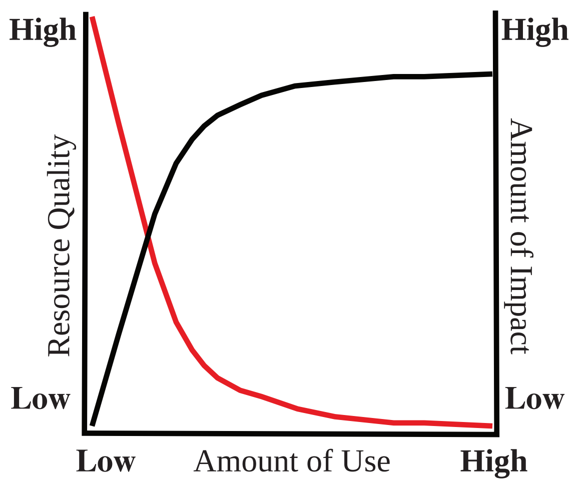
An accurate, timely measure of visitor numbers is necessary to implement the most appropriate management strategy. If it is recorded that July, August, and September visitation is increasing every year, managers may wish to have more volunteers on site educating the public or close the trail to minimize impacts during the elk breeding season. This is something that could be done relatively inexpensively. A pneumatic tube car counter could be placed at the tule elk reserve entrance on Pierce Point Road. The price

of a traffic counter ranges from about $400 for totalizers that merely increase a count for every hose hit, to several thousand dollars for more advanced counters (vehiclecounters.com).

The indirect management actions mentioned above that do not require substantial investment of time and resources should be implemented first. More direct management action such as trail closure or trail redesign should be implemented only as a last resort. The author does not advocate for the closure of the Tomales Point trail because in order to promote environmental stewardship, people must be given access to charismatic species such as the tule elk.

In addition, most resource impacts tend to be related to visitor use levels in a curvilinear manner (Marion 1998; Smith and Hellmund 1993) (see figure 29). In other words, low visitor use causes a disproportionate amount of impact and as use increases there is little change in the amount of impact.

Figure 29: Graph Showing Curvilinear Recreation Impact-User Level Relationship*



*Generalized asymptotic relationships between amount of use and amount of impact (black) and amount of use and resource quality (red). As use levels increase incrementally from low levels, they have a pronounced effect on the amount of impact. However, at medium to high use levels, the amount of impact starts to level off. Furthermore, as use levels increase incrementally from low levels, it has a pronounced effect on resource quality, eventually levelling off when the resource is degraded or destroyed. Adapted from Smith and Hellmund (1993).

Given What Has Been Found, What Should Be Done In The Future?

A similar survey to the one used in this report should be conducted in the spring to compare the responses in the fall with spring recreationists to see if there are any similarities or differences. Also, there are potentially many more ways the data could be analyzed to show more relationships or patterns among the different variables.

In addition, if new signs are installed at Tomales Point, a follow-up survey should be conducted to see if visitor behavior and perceptions have changed, and to see if the signs have had any effect.

Also, more information needs to be collected about horseback riders at Tomales Point and boaters that access the Point from Avalis or other beaches. These two user groups were not represented in this report but their needs should be considered before implementing future management actions.

A more accurate map than the one used in this report should be used in future surveys to potentially increase the accuracy of respondent's markings. It may have been possible to achieve more accurate results if a map with hillshading or topography was used.

In addition, survey respondents may not have been entirely truthful in their answers which may have affected the survey results. People may answer survey questions in a way that they think is most socially desirable, but actually behave in a different manner (Edwards 1957). However, the sample size was large enough to hopefully account for this. Moreover, the author introduced himself as a student from UC Berkeley and told people he was not a park employee in an attempt to encourage them to answer honestly.

This report may have been able to produce more robust results if the author had access to true elk densities derived from telemetry or GPS collared elk and true densities of people within the park. It would have then been possible to compare the results from this report with the tracking data to see how closely they compared. However, it would not have been possible to put tracking devices on people before they started their hike and the author was not able to have access to elk density data in time for this report's deadline.

In the absence of expensive, time consuming, specific locational data for people and wildlife, the method used for this report can provide park managers with a quick, cost effective way to identify areas of interaction between recreationists and sensitive wildlife. Knowing where park visitors are within a park is essential to reducing conflict between recreationists and wildlife. Park managers may know which areas a species inhabits, but without knowing what areas are used by people there is no way to know if that species is at risk from human disturbance.

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APPENDICES

APPENDIX A
TOMALES POINT SURVEY

Tomales Point Trail Visitor Survey

Please fill out the survey below regarding your hike at Tomales Point today. There are no wrong or right answers. Please answer the questions to the best of your ability. **THERE ARE 5 PAGES TOTAL**

1. Please use the map on the next page to

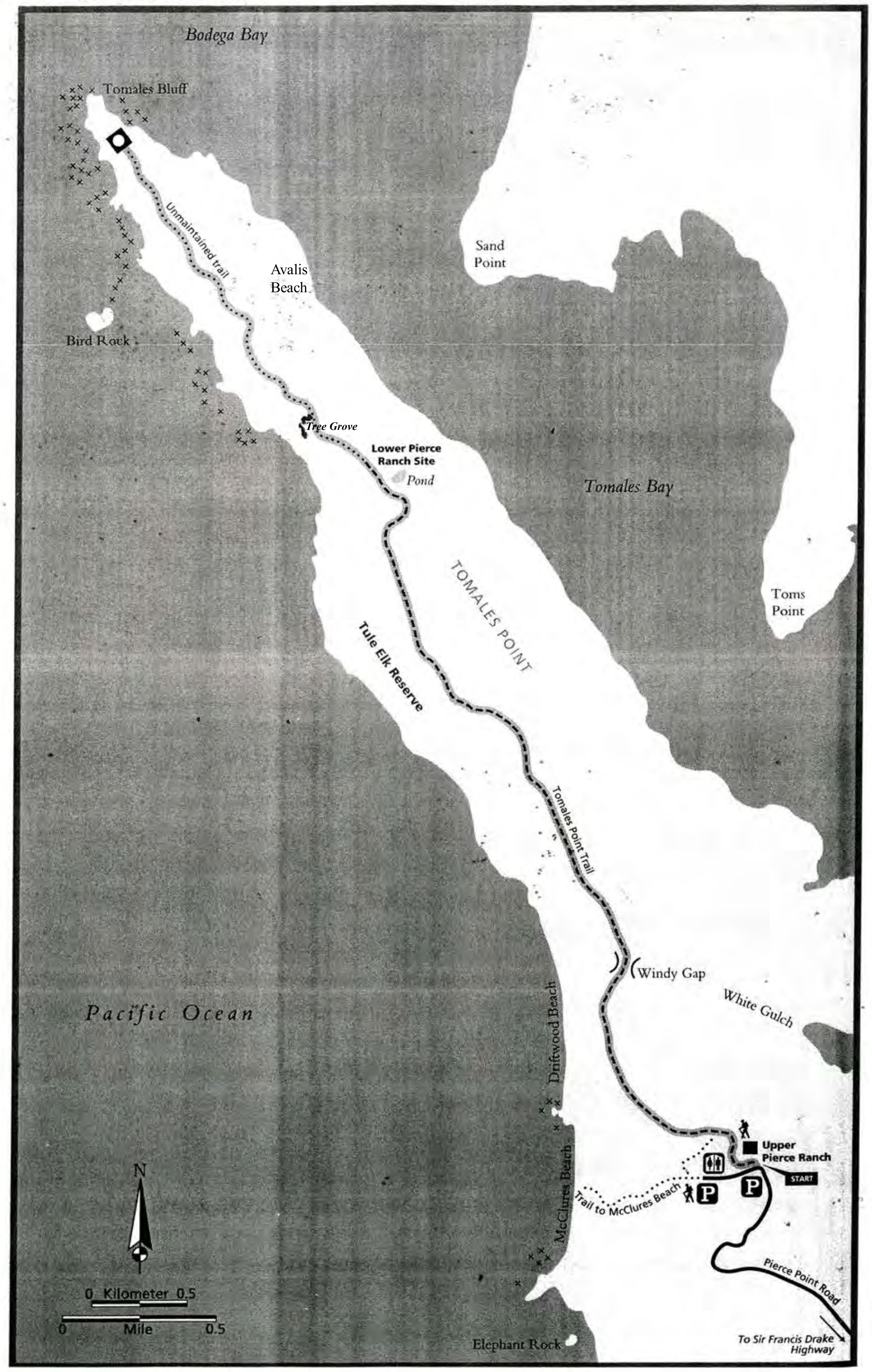
1.) Draw a line on the trail showing how far you hiked today

2.) Mark with an "O" where the elk were (if you saw any)

3.) Mark with an "X" where you went off-trail for any reason

4.) Mark with an "S" where you stopped to rest or eat lunch

Tomales Point Trail



2a. What motivated you to come to Tomales Point today? (Please circle all that apply)

Hiking	Wildflowers
horseback riding	vacation
Birdwatching	solitude
whalewatching	spend time with family/friend(s)
viewing Tule elk	honeymoon
stress relief	other? (please describe)

2b. Please rate the following types of experiences by level of importance

Experience	***How important was this experience?***				
	Not Important				**Very Important**
Hiking/exercise	**1**	**2**	**3**	**4**	**5**
Biking	**1**	**2**	**3**	**4**	**5**
Horseback riding	**1**	**2**	**3**	**4**	**5**
Birdwatching	**1**	**2**	**3**	**4**	**5**
Whalewatching	**1**	**2**	**3**	**4**	**5**
Viewing Tule elk	**1**	**2**	**3**	**4**	**5**
Stress Relief	**1**	**2**	**3**	**4**	**5**
Wildflowers	**1**	**2**	**3**	**4**	**5**
Solitude	**1**	**2**	**3**	**4**	**5**
Spend time with family/friends	**1**	**2**	**3**	**4**	**5**
Experience something new	**1**	**2**	**3**	**4**	**5**
Be in a wild undeveloped place	**1**	**2**	**3**	**4**	**5**
Other? ___________	**1**	**2**	**3**	**4**	**5**

3. How many people are in your group? (Please circle one)

1 2 3 4 5 6 7 8 9 10 over 10

4. How long were you on the trail today? (please circle one)

Less than an hour 1-2 hours 2-3 hours 3-4 hours 4-5 hours over 6 hours

5. How many times have you been to Tomales Point?

1 2-5 6-10 11-20 over 20

6. When hiking, are you actively looking for wildlife or are encounters with wildlife accidental or unintended? (Please circle one)

actively looking (intentional) accidental

7. How frequently have you gone off-trail to photograph or view wildlife?

Very frequently frequently occasionally rarely never

8. How close do you think people can approach Tule elk before they are disturbed?(Width of parking lot is about 100 feet)

(50feet or less) (100 feet) (200 feet) (300 feet) (greater than 300ft)

9a. Did you see any Tule elk on your hike today?

Yes No

9b. If yes, what was the closest you were able to get to the elk? (Width of parking lot is about 100 feet)

10. Did you go off the main trail to get a closer look at the elk? If yes, how far (in feet)?

Yes No _________

11. How did the elk respond to you? (Please circle the most common response)

No response Lifted head and resumed eating/resting Stood up

Walked away Ran away

12. Do you agree that human recreation has the potential to negatively impact the Tule elk?

Strongly agree agree undecided disagree strongly disagree

13. If you found out that human recreation was negatively affecting the Tule elk, what management action(s) would you support? (Please check all that apply)

1.) Close the trail where and when impacts are greatest _____

2.) Require people to keep a minimum distance between elk and themselves _____

3.) Require/encourage people to stay on the trail _____

4.) Limit visitor group size _____

5.) Require people to view an informational video before getting access to trails _____

6.) Have guided hikes with trained docents in elk ecology _____

7.) Install educational signs with information about Tule elk (ecology/life history) and how to reduce recreational impacts ____

8.) Use signs to encourage people to speak softly when hiking on the trail _____

9.) Other? Please describe _____

10.) I would support no new management actions _____

14. Which of the following best describes your experience at Tomales Point today? (Please circle one)

Very pleasant somewhat pleasant neither pleasant nor unpleasant unpleasant

Very unpleasant

15. How would you rate the quality of the Tomales Point trail?

Very good good acceptable poor very poor

16. Where are you visiting from today?

The Bay Area Outside the Bay Area (other parts of California)

Another state Outside the United States

17. What is your gender?

Male Female

18. What is your age? (Please circle one)

18-29 30-39 40-49 50-59 over 60

19. What is the highest level of education you completed? (please circle one)

8th grade High school/GED 2-year college (AA/AS) 4-year college (BA/BS)

Masters PhD. Professional degree (MD/JD)

Thank you for your time!

APPENDIX B:
HUMAN SUBJECTS APPROVAL

UNIVERSITY OF CALIFORNIA AT BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO | SAN FRANCISCO • SANTA BARBARA • SANTA CRUZ

OFFICE FOR THE PROTECTION OF HUMAN SUBJECTS
University of California, Berkeley
2150 Shattuck Avenue, Suite 313
Berkeley, CA 94704 -5940

(510) 642-7461
Fax: (510) 643-6272
Website: http://cphs.berkeley.edu
FWA#00006252

October 29, 2008

CHRISTOPHER MOI (moi@berkeley.edu)
Landscape Architecture and Environmental Planning
470 Bernice Lane MC#
Sonoma, CA 94576

RE: **CPHS Protocol #2008-9-47**
"An Approach to reduce recreation impacts on wildlife" - Graduate Research - - Landscape Architecture and Environmental Planning

Dear Mr. MOI

Thank you for the statement and request for exemption that you submitted to the Committee for the above-referenced project. Your submission has been reviewed and granted exemption, as it satisfies the Committee's requirements under category #2(a) of the federal regulations. Accordingly, the project is exempt from full Committee review provided that there are no changes in the use of human subjects.

Please note that although your research has been deemed exempt from full committee and subcommittee review, you still have a responsibility to protect your subjects, and the research should be conducted in accordance with the principles of the Belmont Report. Download the Belmont Report at this link:
http://www.hhs.gov/ohrp/humansubjects/guidance/belmont.htm.

If you have any questions about this matter, please contact the OPHS staff at 642-7461; FAX 643-6272; E-Mail ophs@berkeley.edu.

Sincerely,

Rebecca Armstrong

Rebecca Armstrong, D.V.M, Ph.D
Director, Office for the Protection of Human Subjects

RA: kmb

Cc: Joe McBride (jrm@nature.berkeley.edu)
Graduate Division (degrees@berkeley.edu) - SID # 19883984
SPO# (spo_acuc_ophs@lists.berkeley.edu)

APPENDIX C:
NATIONAL PARK SERVICE RESEARCH PERMIT

SCIENTIFIC RESEARCH AND COLLECTING PERMIT Grants permission in accordance with the attached general and special conditions United States Department of the Interior National Park Service Point Reyes NS	**Study#: PORE-00482** **Permit#: PORE-2008-SCI-0040** **Start Date: Oct 16, 2008** **Expiration Date: Dec 31, 2009** **Coop Agreement#: n/a** **Optional Park Code: n/a**

Name of principal investigator:

Name: Christopher Moi **Phone:** 7077586798 **Email:** moi@berkeley.edu

Name of institution represented:

University of California - Berkeley

Co-Investigators:

No co-investigators

Project title:

An approach for park managers to reduce recreational impacts on wildlife.

Purpose of study:

I hypothesize that if visitors to Tomales Point were aware that they were having a negative effect on the Tule elk there would be a reduction in recreational impact. Studies have shown that educating visitors on how to minimize impacts to wildlife reduced visitor impact. In addition recreationist perceptions regarding their effects on wildlife may influence their behavior on public lands and knowledge of visitor perceptions can help managers encourage positive visitor behavior between wildlife and them.

Therefore, I will survey visitors to the Tomales Point trail to investigate what their perception is regarding recreational effects on wildlife, specifically the tule elk, and to gather information about their behavior.

I predict that most people will not think recreation has an impact on the Tule elk at Tomales Point. I will also ask people what motivated them to hike at Tomales Point to get an idea what might be driving peopleâ s behavior when recreating there.

Ultimately, I hope to use the visitor responses to the survey in addition to existing park data on elk-visitor interaction to develop management recommendations for park managers that will balance recreation and conservation at Point Reyes National Seashore.

Subject/Discipline:

Mammals

Locations authorized:

Tomales Point trail. In the parking lot of the trailhead and at locations to be determined along the Tomales Point trail.

Camera Purpose and Placement:

I will place one camera along the spur trail at

> White Gulch and one camera at Avalis Beach to count people hiking onto

> Tomales Point after landing on the beach with boats or kayaks.

>
> In addition, I will place one more camera at the entrance to the Tule
> elk reserve on Pierce Point Road to get a more accurate count of
> visitors to Tomales Point. I will securely fasten the camera with a
> lock to a fence post at the entrance to the reserve.
>

Transportation method to research site(s):

I will access the trail by foot and use my car to get to the trailhead parking lot from my house.

Collection of the following specimens or materials, quantities, and any limitations on collecting:

No collecting

Name of repository for specimens or sample materials if applicable:

n/a

Specific conditions or restrictions (also see attached conditions):

CARRY PERMIT WHILE WORKING AND LEAVE RESEARCH PLACARD ON DASHBOARD OF VEHICLE. ALL COLLECTIONS MUST BE MADE WITH MINIMAL IMPACT TO THE PARK'S RESOURCES AND VISITORS. Collect as few specimens as practical; in no case should the continued survival of a population of any species be jeopardized by your activities.

ALL TRAPS, TAGS, ETC., WHICH ARE TEMPORARILY LEFT IN THE FIELD MUST BE MARKED WITH YOUR PERMANENT STUDY NUMBER (for example: PORE-0019). They must be as unobtrusive as possible and must not interfere with visitor enjoyment of the park as a natural area.

PLASTIC FLAGGING SHOULD BE USED SPARINGLY AND MUST BE MARKED WITH YOUR STUDY NUMBER. It must be out of sight of trails and roads during all seasons, and it must be removed upon completion of your research project.

PLEASE CONDUCT YOUR ACTIVITIES OUT OF SIGHT OF HEAVILY USED VISITOR AREAS. Please work on weekdays when possible.

YOU ARE REQUIRED TO SUBMIT AN ONLINE REPORT OF YOUR RESEARCH ACTIVITIES EACH YEAR, and you must mail two copies of your final research report and any publications to our office upon completion of your project.

YOU MUST DELIVER GPS POINTS (NAD83 UTM Zone 10) of any permanent or temporary research plots to ben_becker@nps.gov within 7 days of establishing plots. Please include your permit number and name with the email. AVOID introducing weed seeds and propagules.

Recommended by park staff(name and title):

Becker / Gates / Smith / Fellers

Reviewed by Collections Manager:

Yes ___ No X

Approved by park official:

Date Approved:

10/27/08

Title:

Superintendent

I Agree To All Conditions And Restrictions Of this Permit As Specified
(Not valid unless signed and dated by the principal investigator)

Christopher Moi

(Principal investigator's signature)

10/29/08

(Date)

THIS PERMIT AND ATTACHED CONDITIONS AND RESTRICTIONS MUST BE CARRIED AT ALL TIMES WHILE CONDUCTING RESEARCH ACTIVITIES IN THE DESIGNATED PARK(S)